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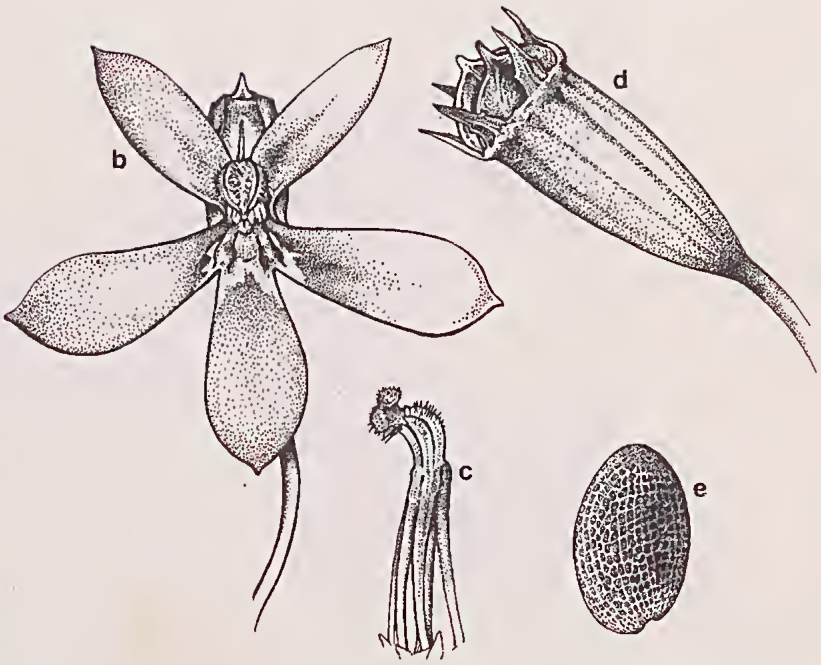

***Lobelia beaugleholei* Albr.**
[*Muelleria* 7(4): 525 (1992)]
Source: State Botanical Collection
Artist: P. Neish

This species was named in honour of Mr A. Cliff Beauglehole of Portland, who recognized the distinctiveness of this taxon from the first sighting. Cliff was a keen naturalist and prolific collector of many unique and intriguing specimens of plants, insects, and fungi.

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Muelleria publishes research papers on Southern Hemisphere plant, algal and fungal taxonomy and systematics, particularly relating to Australia. Acceptable submissions include: taxonomic revisions; phylogenetic and biogeographical studies; short papers describing new taxa, documenting nationally significant new records, or resolving nomenclatural matters; historical analyses relevant to systematics; and any research contributing to our knowledge of plant, algal or fungal diversity. Special issues or reviews will also be considered after discussion with the Editor.

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Type studies of Australian species of *Inocybe* (Agaricales)

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Introduction

In preparation for monographic and floristic studies of the family Inocybaceae (Agaricales, Basidiomycota) from Australia, critical evaluations of type material are required not only to clarify species concepts of original authors but also to reveal the status of characters omitted from protologues or by subsequent type studies. Re-examinations of Australian type collections that have been classified in *Inocybe* by various authors are presented here. This work includes twelve types of Cleland (Cleland and Cheel 1918; Cleland 1928; Cleland 1933), one type of Miller and Hilton (1987), and three types of Grgurinovic (1997). Although Horak (Horak 1977; 1979; 1980; 1981) described numerous species of *Inocybe* (also as *Astrosporina*, here treated as a synonym of *Inocybe*) from southeast Asia, Indonesia, Papua New Guinea, and New Zealand, no new species were described by him from Australia. Five species have been recently described in or transferred to the genus *Auritella*. See Matheny and Bougher (2006a, 2006b) for complete descriptions of these species. Because details of the type collection of *A. arenicolens* (=*Naucoria arenacolens*) were not presented separately, they are presented here.

Two species of *Inocybe* previously considered doubtful because authentic material could not be located at AD (Grgurinovic 1997) are clarified here with the recovery of Cleland's material on which the protologues were based. These recovered collections are designated as lectotypes. A key to 17 described species of Inocybaceae is provided. Documentation and description of Inocybaceae from Australia is ongoing and will yield numerous novel taxa, but a key at present should prove useful to discriminate known taxa from potentially undescribed species.

Materials and methods

Tissues were revived in 3% KOH and spores examined in both KOH and Melzer's solution using light microscopy. Line drawings were made with the assistance of a drawing tube. Basidiospores were drawn at 2000×. Other cells were drawn at 800×. Anatomical terminology such as cauloparacystidia and caulocystidioid hairs follows Kuyper (1986). Colours of microscopic features quoted in the descriptions of taxa are for

Abstract

Twenty-eight species of Inocybaceae Jülich (order Agaricales) have been described from Australia. Five are included in the genus *Auritello* Matheny & Bougher, but the remaining twenty-three are in need of evaluation in order to facilitate mycofloristic studies of Australian fungi. Of these twenty-three species, twelve are treated in *Inocybe* (Fr.) Fr., and eleven are excluded or treated as doubtful. Three species treated as synonyms in the past are considered here to be autonomous. *Inocybe cystidiocatenoto* Grgurinovic is a synonym of *I. fibrilloso* (Cleland) Grgurinovic non Peck, for which the generic placement is *Cortinarius*. *Inocybe striotula* (Cleland) Grgurinovic also belongs to *Cortinorius*. The new combination *Pholioto morongania* (Grgurinovic) Matheny & Bougher is made. *Inocybe colopedes* Matheny & Bougher is introduced as a new name for *I. discissa* Cleland, non *I. descisso* (Fr.) Quél. Five lectotypes of *Inocybe* species are designated, thirteen species are illustrated, and a key to currently accepted species of Inocybaceae from Australia is provided.

Keywords: *Inocybe*, taxonomy, lectotype, Inocybaceae

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Key to described species of Inocybaceae accepted from Australia

1 Fruitbodies sequestrate with a partial stipe-columella, peridium pallid mixed with brownish areas, loculate, dark brown; basidia necropigmented, spores smooth, ovate-elliptic, 9.0–10.5 × 5.5–6.0 µm ..... ***Auritella geoaustralis*** Matheny & Bougher (see Matheny & Bougher, 2006a)

1: Fruitbodies agaricoid and basidia necropigmented or hyaline 2

2 Fruitbodies often short and squat in sand or sandy soil, pale brown to dark brown; spores narrowly oblong-cylindric or oblong-reniform, 10–14 × 4.0–5.5 µm, very pale brown or warm buff under a light microscope, pleurocystidia absent, cheilocystidia often elongated and cylindric, 49–92 × 6–13 µm ... ***Auritella arenicolens*** (Cleland) Matheny & Bougher (see below, also Matheny & Bougher, 2006a)

2: Fruitbodies not short and squat, spores not narrowly oblong, spores generally yellowish brown or darker than above, habitat various, colour various; pleurocystidia absent or present but cheilocystidia not elongated and cylindric 3

3 Basidia necropigmented and pleurocystidia absent; partial veil absent, lacking marginate bulb 4

3: Basidia hyaline and pleurocystidia present as metuloids; partial veil present as a cortina, or absent if possessing a marginate bulb 6

4 Pileus fulvous to hazel, surface minutely velvety; cheilocystidia narrowly flexuous with obtuse apices, 35–72 × 5–10 µm, spores 8.0–9.5 × 5.0–5.5 µm, subphaseoliform, subamygdaliform to elliptic ..... ***Auritella serpentinacystis*** Matheny, Trappe & Bougher (see Matheny & Bougher, 2006a)

4: Pileus some other colour and not minutely velvety; cheilocystidia subfusiform, sublageniform to slenderly clavate with swollen or subcapitate apices 5

5 Known from New South Wales, spores normally pigmented or ochraceous-tawny under a light microscope, 7.5–10.5 × 4.0–5.5 µm, elliptic, pileus light yellowish brown to light brown, stipe pallid to pale brown or coloured like pileus ..... ***Auritella dolichocystis*** Matheny, Trappe & Bougher (see Matheny & Bougher, 2006a)

5: Known from Western Australia, spores lighter than above or ochraceous-buff under a light microscope, morphologically similar to above but differing in nL5U-rRNA and *rpb2* nucleotide sequences ..... ***Auritella chamaecephala*** Matheny, O.K. Mill. & Bougher (see Matheny & Bougher, 2006a)

6 Spores smooth or entire in outline 7

6: Spores angular or nodulose in outline 13

7 Stipe violet, pileus with violet covering at first, later cinnamon-brown to umbrinous, odour strongly spermatic; spores elliptic and caulocystidia and caulocystidioid hairs absent ..... ***Inocybe violaceocaulis*** Matheny & Bougher (see Matheny & Bougher 2005)

7: Violet pigments absent, odour not strongly spermatic; spores not elliptic, caulocystidia or caulocystidioid hairs present 8

8 Pileus brown or umbrinous, matted fibrillose-squamulose, stipe coarsely pubescent with tufts of minute fibrils, not pruinose; pleurocystidia quite long between 70–110 µm, spores 8.5–10.5 µm × 5.0–6.0 µm ..... ***Inocybe fibrillosibrunnea*** Miller & Hilton

8: Pileus colour various, surface texture various, stipe pruinose entire length or at apex; pleurocystidia <80 µm long, spores of various dimensions 9

9 Centre of pileus squarrose-scaly to imbricate-scaly, dark brown to almost black, at least upper half of stipe pruinose; spores elliptic to ovate, short, 6.5–7.5 × 4.0–5.0 µm ..... ***Inocybe australlensis*** Cleland & Cheel

9: Pileus not squarrose-scaly, colour and stipe covering various; spores as above or larger 10

10 Pileus brown or tawny-olive, stipe with pink or pinkish-cinnamon tones; spores 6.5–7.5 × 4.0–5.0 µm ..... ***Inocybe fulvo-olivacea*** Cleland

10: Pileus reddish brown to dark umbrinous, cinnamon brown, or yellowish brown to dark yellowish brown, stipe warm buff or lacking pink tones, or spores larger than above 11

11 5pores 10.0–11.0 × 5.0–5.0 µm, pileus cinnamon brown to umber brown, stipe similarly coloured to pileus ..... ***Inocybe murrayana*** Cleland

11: Spores <10.0 µm long, pileus and stipe variously coloured 12

12 Pileus dark brown to brown or umbrinous ..... ***Inocybe granulosipes*** Cleland

12: Pileus pale brown ..... ***Inocybe serrata*** Cleland

13 Base of stipe marginate or weakly so 14

13: Stipe even or swollen at base, but not with a marginate bulb 15

14 Pileus reddish brown, rimose, lamellae almost free, stipe longer than pileus diameter; spores 9.0–10.5 × 6.5–7.5 µm with 9–10 prominent nodules ..... ***Inocybe calopedes*** Matheny & Bougher

14: Pileus pale yellowish brown, not rimose, lamellae attached, stipe short in relation to pileus diameter; spores 8.5–10 × 5.0–6.0 µm with 7–9 indistinct nodules or corners about an angular outline, the ventral side of which is often concave ..... ***Inocybe emergens*** (Cleland) Grgurinovic

15 Caulocystidia descending entire length of stipe; pileus cinnamon-brown, stipe white; spores 8.0–10.5 × 6.0–7.0 µm with 9–13 moderate to prominently size nodules ..... ***Inocybe exigua*** (Cleland) Grgurinovic

15: Caulocystidia restricted to stipe apex or not observed 16

16 Pileus dark brown, shaggy squamulose; stipe pale brown, not stout, fibrillose; spores 9.5–11.0 × 5.5–6.5 µm, oblong-angular with 5–8 inconspicuous nodules or corners; metuloid caulocystidia not observed ..... ***Inocybe imbricata*** (Cleland) Garrido

16: Pileus golden brown, rimose; stipe stout, striate, with pale brown tint; spores 9.0–11.5 × 6.5–8.0 µm, gibbous with 9–12 small nodules but others irregularly angular to subelliptic in outline with 7–9 indistinct nodules or corners; metuloid caulocystidia present at stipe apex ..... ***Inocybe dewrangia*** Grgurinovic

material mounted in KOH unless indicated otherwise. Microscopic descriptions are our own, except for dimensions reported in Cleland's protologues or where cited from literature sources.

Herbarium abbreviations are made according to Holmgren *et al.* (1990). Colour references to spores under the microscope were made with Ridgway (1912) and/or Munsell Soil Color Charts (1954).

Original Latin diagnoses by Cleland are included because they can be necessary to clarify species concepts based on heterogeneous collections.

Taxonomy

1. *Auritella arenicolens* (Cleland) Matheny & Bougher, *Mycotaxon* 97: 232 (2006)

Naucoria arenacolens Cleland, *Trans. Roy. Soc. S. Aust.* 57: 193 (1933); *Inocybe arenacolens* (Cleland) Horak, *Persoonia* 11: 6 (1980); *Auritella arenicolens* (Cleland) Matheny & Bougher, *nom. inval.* Art. 43.1

[Protologue] *Pileus 2.5–4.4 cm, convexus, deinde expansus, subirregularis, innato-fibrillosus, "Sayal Brown". Lamellae sinuatae, subconfertae, perventricosae, 3–5 mm latae, marginibus pallidioribus et minute serratis, tabacino-brunneae. Stipes 2.5–3.7 cm, subcrassus (8–10 mm), aequalis, fibrillosus, solidus, subcarneo-alutaceo-pallidus. Sporae pallido-brunneae, elongatae, 9.5–13 × 4 µm. Encounter Bay, South Australia, May.*

Basidiospores (10.0–) 11.0–14.0 × 4.0–4.5 (–5.0) µm, smooth, oblong-elliptic or narrowly cylindric with a suprahilar depression, pale yellowish brown in KOH or "Warm Buff" to "Chamois", unchanging colour in Melzer's solution, ± thin-walled, germ pore absent, apiculus indistinct. *Basidia* 42–57 × 7–10 µm, 4-sterigmate, slenderly subclavate, ochraceous to hyaline. *Pleurocystidia* absent. *Cheilocystidia* 47–108 × 8–14 µm, clyindric or slenderly subclavate, thin-walled, ochraceous to hyaline. *Caulocystidia* absent. *Lamellar trama* regular, ochraceous in mass, hyphae cylindric, up to 10 µm broad, dark ochraceous refractive hyphae present. *Pileipellis* not studied. *Clamps* present.

***Specimens examined*: SOUTH AUSTRALIA.** Lectotype, Encounter Bay, Waitpinga Road, emerging from sandy soil, 27.v.1932, *J.B. Cleland* (AD 12222); Encounter Bay, in sand, 27.v.1933, *J.B. Cleland* (AD 12261); Encounter Bay, in sand, 22.v.1930, *J.B. Cleland* (AD 12262).

Notes: Additional collections of *A. arenicolens*—note correction in spelling of the specific epithet (Matheny and Bougher 2006b)—have been cited from Western Australia and a composite description has been produced (Matheny and Bougher 2006a). Variation in spore size has also been observed, which should prompt DNA-based comparisons between collections. Species of *Auritella* can be distinguished from species of *Inocybe* by the following combination

of characters: somber brown colours, distinctly fimbriate lamellar edges, presence of necropigmented basidia, long cheilocystidia (often longer than 50 µm), non-rimose pileus, lack of reddening context, Gondwanan geographic distribution (India, Africa, and Australia, Matheny and Pradeep, unpublished), and unique phylogenetic placement (Matheny *et al.* 2009).

2. *Inocybe australiensis* Cleland & Cheel, *Trans. Roy. Soc. S. Aust.* 42: 109 (1918)

[Protologue] *Pileus ad 1.5 cm latus, convexus, interdum paulo umbonatus, squamis subnigris fibrosis vestitus. Lamellae adnexae, confertae, cinnamoneae vel atro-fuscae. Stipes 3 cm altus, pallido-fuscus aut fuscus, sursum farinosus, non tubulosus, base minime bulbosa. Sporae fuscae, glabrae, obliquae, 6–7 × 4–5 µm. Cystidia ventricosa vel angusto-ventricosa, 50–70 × 10.5, 42 × 8.5 µm. Neutral Bay, Sydney, New South Wales, May.*

Basidiospores 6.5–7.5 × 4.0–5.0 µm (n=20), smooth, elliptic to ovate with rounded apices, occasionally subamygdaliform, with slightly thick wall, apiculus small but distinct, yellowish brown. *Basidia* 25–27 × 6 µm, hyaline, collapsed. *Pleurocystidia* 47–60 × 12–14 µm, fusiform, thick-walled, walls 2.5–4.0 µm thick, pale yellow, necks developed or not, often merely tapered upwards and below from a central ventricose portion; apices obtuse, at times bearing crystals. *Cheilocystidia* not studied. *Caulocystidia* mostly larger than pleurocystidia, 72–85 × 16–22 µm, and often lageniform, descending to centre of stipe with cauloparacystidia; base of stipe with caulocystidioid hairs, cauloparacystidia not observed. *Pileipellis* composed of broad fascicles of trichodermial hyphae that are "Tawny" in mass, pigment dissolves in KOH, hyphae thin-walled to slightly thickened, cylindric to inflated, up to 18 µm diam, incrusting pigments not evident in KOH. *Clamps* present. Fig. 1.

***Specimens examined*: NEW SOUTH WALES.** Lectotype here designated, Neutral Bay, 9 May 1915, *J.B. Cleland* (AD 5455); Sydney, Chatswood, 21.v.1916, *J.B. Cleland* (AD 5456) (watercolour 96 by Miss Clarke, not seen by us); Sydney, no date but "pre-1920" written on the packet, *J.B. Cleland* (AD 5457) (not cited in protologue).

Notes: The microscopic study is in agreement with Horak (1980). However, contrary to Horak *Inocybe australiensis* is not synonymous with *I. serrata* Cleland and *I. granulosipes* Cleland based on comparison of gross morphological characters. The original diagnoses are repeated to emphasise this point. *Inocybe australiensis* is distinguished by its squarrose dark brown pileus (similar to *I. lanuginosa*), upper half of the stipe that is pruinose, and small elliptic spores. The lower part of the stipe is fibrillose based on the presence of dense superficial fibrils there. Unfortunately, no data exist on the habitat associated with this species originally described from New South Wales. Similar species include *I. phaeosquarrosa* Horak from New Zealand, which differs by the scaly stipe and thin-walled cystidia; and *I. umbrosa* Horak, which has a red brown pruinose stipe and amygdaliform shaped spores.

The name *Inocybe australiensis* has been misapplied to collections of *I. serrata* and closely related species by Grgurinovic (1997) and Bougher and Syme (1998). It is not known at this time from Western Australia.

The description in the protologue is almost drawn entirely from AD 5455 incorporating minor aspects of AD 5456. AD 5457, which is not referred to in the protologue, is conspecific.

3. *Inocybe calopedes* Matheny & Bougher, *nom. nov.*

Inocybe discissa (Cleland) Grgurinovic, *Larger Fungi of S. Aust.* 182 (1997), *non Inocybe descissa* (Fr.) Quél. (1872); *Astrosporina discissa* Cleland, *Trans. Roy. Soc. S. Aust.* 57: 192 (1933).

[Protologue] *Pileus 2.5 cm, convexus, umbonatus, perfibrillosus, discissus, brunneus. Lamellae liberae, ventricosae, brunneae. Stipes 2.5 cm, subtenuis, primitus subpruinosus deinde glaber, aequalis, ad basim sub-bulbous, albidus vel pallido-brunneus. Sporae nodosae, brunneae, 9 × 6 µm. Upper Tunkalilla Creek, South Australia, June.*

Basidiospores (8.5–) 9.0–10.5 (–11.0) × 6.5–7.5 µm (n=20), gibbous with mostly 9–10 prominent obtusely conic nodules around a polygonal outline, saddle-shaped nodules rare, with distinct apiculus, yellowish brown, not reacting in Melzer's. *Basidia* 23–28 × 9–10 µm, 4-sterigmate, clavate to cylindrico-clavate, hyaline. *Pleurocystidia* 49–58 × 16–25 µm, fusiform to utriform, thick-walled, walls 2.0–4.0 µm thick, hyaline

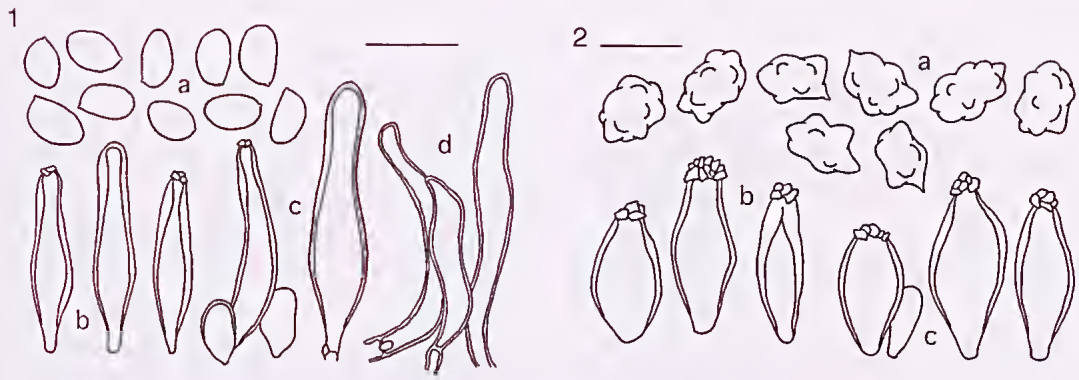


Figure 1: *Inocybe australiensis* (AD5455, lectotype): a. spores; b. pleurocystidia; c. caulocystidia from stipe apex; d. caulocystidioid hairs above stipe base. Scale bar = 10 µm for spores, 25 µm for other cells.
Figure 2: *Inocybe calopedes* (AD12230, holotype of *Astrosporina discisso*): a. spores; b. pleurocystidia; c. caulocystidia from throughout the stipe. Scale bar = 10 µm for spores, 25 µm for other cells.

or pale yellowish, with or without a short neck, tapering below to a short pedicel or sessile; apices obtuse, crystalliferous; not frequent. *Cheilocystidia* similar to pleurocystidia although usually shorter, also clavate, infrequent. *Caulocystidia* similar to pleurocystidia though often more ventricose or rounded, descending entire length of stipe, in clusters mixed with cauloparacystidia down to centre of stipe; less frequent below and usually subelliptic to broadly clavate and thin- or slightly thick-walled. *Lamellar trama* regular, pale yellowish brown in mass, hyphae cylindric to inflated, up to 23 µm diam. *Pileipellis* a cutis of light reddish brown pigmented hyphae in mass, surmounted by a sparse irregular layer of narrowly cylindric, hyaline hyphae. *Clamps* present. Fig. 2.

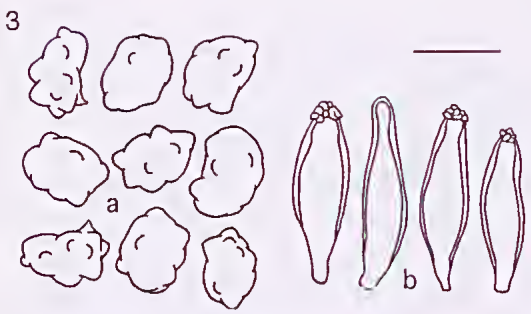
Specimens examined: **SOUTH AUSTRALIA.** Holotype, Upper Tunkallilla Creek, 4.vi.1930, *J.B. Clelond* (AD 12230). **TASMANIA.** I2, Myrtle Gully, 9.xi.2000, *G. Gotes & D. Rotkowsky*, pers. herb. G. Gates; I100 Myrtle Gully, 16.xi.2006, *G. Gotes & D. Ratkowsky*, pers. herb. G. Gates. **WESTERN AUSTRALIA:** E6735 (=PBM2118), just outside William Bay National Park, near Lake Byleveld, 15 km from Denmark, under *Eucolyptus colophyllo* and *Agonis* sp., 23.vi.2001, *N.L Bougher* (PERTH).

Notes: The new name *Inocybe calopedes* is proposed to replace *I. discissa* (Cleland) Grgurinovic, a confusingly similar name to and homonym (Art. 53.3) of *I. descissa* (Fr.) Quél. Grgurinovic (1997) considered *I. discissa* to belong to section *Inocybe* whereas Horak (1979) regarded the species as doubtful, possibly near *I. napipes* Lange, also in section *Inocybe*. However, the stipe covering is pruinose and a weak marginate bulb is present. Caulocystidia and cauloparacystidia can be found descending to the centre of the stipe and less frequently below. The type clearly features a reddish brown rimose pileus. With these characters taken together, an affinity to the taxonomic section *Marginatae* is likely, though taxa ascribed to this section are not monophyletic (Matheny 2005, Ryberg 2009). The qualifying characters of *I. calopedes* include: a reddish brown, rimose pileus; slender pallid to pale brown tinged, pruinose to glabrescent stipe; stipe base with a weak marginate bulb; short fusiform to utriform, thick-walled pleurocystidia; caulocystidia descending the length of the stipe; and gibbous spores with 9–10 prominent nodules. Recent material of this species observed in Western Australia and Tasmania exhibits pinkish tones on the stipe.

4. *Inocybe dewrangia* Grgurinovic, *Larger Fungi of S. Aust.*: 185 (1997)

Inocybe asterospora sensu Cleland & Cheel, *Trans. Roy. Soc. S. Aust.* 42: 105 (1918).

[Description from AD 12298] *Pileus* up to 3.0 cm diam, convex with a large conic al umbo, somewhat golden brown [rimose]. *Lamellae* adnexed, near free, moderately close, cinnamon brown. *Stipe* 3.0 cm long, moderately stout, slightly attenuated upwards, striate, pallid brown tinted, solid, fibrous. Mt. Lofty, South Australia, April.



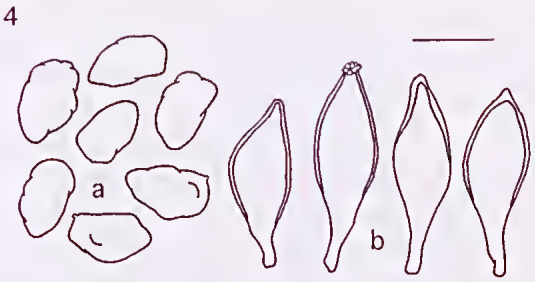


Figure 3: *Inocybe dewrangia* (AD12298, holotype): a. spores; b. pleurocystidia. Scale bar = 10 µm for spores, 25 µm for other cells.
Figure 4: *Inocybe curvipes* (AD12143): a spores; b. pleurocystidia. Scale bar = 10 µm for spores, 25 µm for other cells.

Basidiospores 9.0–11.5 × 6.5–8.0 (–8.5) µm (n=20), gibbous, heteromorphic—some spores with 9–12 small nodules with an irregularly angular to subelliptic outline; other spores pentagonal to polyhedral with 7–9 indistinct nodules or merely corners, these common off lamellar mounts; intermediate spores occur on the stipe surface, not reacting in Melzer's, yellowish brown. *Basidia* 26–33 × 9–11 µm, 4-sterigmate, clavate, hyaline. *Pleurocystidia* 46–60 × 12–19 µm, utriform to fusiform thick-walled, walls 2.0–3.0 µm thick, hyaline to pale yellowish, mostly with short or no necks, with a basal pedicel; apices obtuse, crystalliferous. *Cheilocystidia* similar to pleurocystidia. *Caulocystidia* similar to pleurocystidia but also fusiform to cylindric and up to 85 × 11 µm, restricted to the apex of the stipe, cauloparacystidia not observed, surface of stipe appears infected by an imperfect fungus. *Lamellar trama* not studied. *Pileipellis* a cutis of cylindric hyphae, light reddish brown pigmented in mass, surmounted by a sparse velipellar layer of narrowly cylindric hyphae. *Clamps* present. Figs. 3–4.

Specimens examined: **SOUTH AUSTRALIA.** (=*I. asterospora* sensu Cleland & Cheel), holotype, Mt. Lofty, 7.iv.1917, *J.B. Cleland* (AD 12298); labeled *I. dewrangia*, Belair NP, 12.iv.1917, *J. B. Cleland* (AD 12143) (=*I. curvipes*).

Notes: Cleland's original macroscopic notes are reproduced above to emend the concept of this species, the protologue of which is a composite of *I. dewrangia* (AD 12298, originally labeled *I. asterospora*) (Fig. 3) and *I. curvipes* P. Karsten (AD 12143) (Fig. 4). The protologue (Grgurinovic, 1997) describes the pileus as "fibrilloso-squamosus" and the odor as "strong, rather seminal", two character states not ascribed to the holotype but to AD 12143 also labeled *I. dewrangia*. Unfortunately, AD 12143 is *I. curvipes* P. Karsten, a north temperate species easily identified due to its characteristic broadly ventricose and mucronate pleurocystidia and long, merely angular or indistinctly nodulose spores (Fig. 4). Cleland's collection of this species must have been made under an introduced tree such as *Pinus*, *Quercus*, or *Salix*. In any case, it is not conspecific with the holotype.

Horak studied the collection AD 12298, later designated as the holotype by Grgurinovic, as an undeterminable species of *Astrosporina*. We believe this was the more prudent choice but, unfortunately, must struggle with the limited macroscopic description of the holotype. In sum, *I. dewrangia* appears to be distinctive by the following characters: medium size; golden brown, rimose pileus; finely-fibrillose stipe that is swollen or somewhat enlarged towards the base but not bulbous; caulocystidia restricted to the apex of the stipe; fusiform to utriform, thick-walled pleurocystidia; and the gibbous spores.

5. *Inocybe emergens* (Cleland) Grgurinovic, *Larger Fungi of S. Aust.*: 192 (1997)

Astrosporina emergens Cleland *Trans. Roy. Soc. S. Aust.* 57: 192 (1933).

[Protologue and AD 40426] *Pileus ad 3 cm, ad 1.5 cm procerus, irregulariter lato-conicus, subfibrillosus vel subglaber, pallido-luteus. Lamellae adnatae vel adnexae, confertae, pallido-brunnneae. Stipes ad 2.5*

cm, subcrassus, ad basim sub-bulbous, albus, deinde sub-brunneo-albidus. Sporae angulatae, pallido-brunnae, 7.5 × 4 µm. Cystidia ampullaformia apicibus asperis, 25–37 × 13 µm. Kinchina, South Australia, June.

Basidiospores 8.5–10.0 (–10.5) × 5.0–6.0 µm (n=20), gibbous with 7–9 small inconspicuous nodules or corners around an angular outline, of which the ventral side is often concave, apiculus distinct, yellowish brown. *Basidia* 28–35 × 9–11 µm, 4-sterigmate, clavate, hyaline. *Pleurocystidia* 45–72 × 14–22 µm, utriform to broadly fusiform, without or with very short necks, thick-walled, walls 2.5–5.0 µm thick, hyaline to pale yellowish; apices rounded to obtuse, bearing crystals; with a basal pedicel, not frequent. *Cheilocystidia* not studied. *Caulocystidia* similar to pleurocystidia, at times larger and thin-walled, often utriform to broadly cylindric, in scattered clusters with a few cauloparacystidia—small clavate cells, thin-walled, hyaline—descending to the base of the stipe. *Lamellar trama* regular, pale yellowish brown or ochraceous in mass, hyphae cylindric. *Pileipellis* with a suprapellis of irregular to subregular layer of narrowly cylindric velipellar hyaphe, these smooth, thin-walled, hyaline; subpellis light ochraceous pigmented in mass, hyphae cylindric to inflated, up to 25 µm diam. *Clamps* present. Fig. 5.

Specimens examined: **SOUTH AUSTRALIA.** Lectotype here designated, Kinchina, 8.vi.1925, *J.B. Cleland* (AD 40426).

Notes: The lectotype consists of numerous specimens in satisfactory condition. Cleland's notes that accompany AD 40426 leave no doubt this collection is the source of the information in the protologue. *Inocybe emergens* is distinctive by virtue of its pale yellowish brown, finely-fibrillose pileus; short, stout, pruinose stipe that is pallid and becomes tinged brown; marginately bulbous base; and weakly gibbous spores with an unusual concave depression on the ventral side when viewed in profile. *Inocybe imbricata* (Cleland) Garrido shares the peculiar spore outline, but is readily distinguished by its squamulose pileus and lack of caulocystidia on the stipe.

6. *Inocybe exigua* (Cleland) Grgurinovic, *Larger Fungi of S. Aust*: 184 (1997)

Astrosporina exigua Cleland, *Trans. Roy. Soc. S. Aust.* 57: 192 (1933).

[Protologue] *Pileus ad 1.2 cm, convexus vel campanulatus, subfibrillosus, cinnamoneo-brunneus. Lamellae adnatae, subconfertae, subcinnamoneae. Stipes 1.2 cm, subfibrillosus, albidus. Sporae nodosae, 8.0–8.5 µm. Cystidia pauca ampullaformia apicibus glabris. Hope Valley, South Australia, April.*

Basidiospores 8.0–10.5 × 6.0–7.0 (–7.5) µm (n=20), gibbous with 9–13 conspicuous or moderate to prominent-sized nodules around a subelliptic to angular outline, similar in shape to *Inocybe lanuginosa* and *I. stellatospora*, with a small apiculus, yellowish brown, not reacting in Melzer's. *Basidia* 26–38 × 8–10 µm, 4-sterigmate, clavate, hyaline. *Pleurocystidia* 32–65 × 15–27 µm, saccate, pyriform, to utriform with well-rounded apices, typically thin-walled but at times with thickened apically and up to 1.5 µm thick, hyaline, apices occasionally crystalliferous, with a short pedicel, infrequent. *Cheilocystidia* not studied. *Caulocystidia* descending the entire length of the stipe but less frequent on the lower half, similar to pleurocystidia, thin-walled, paracystidia not observed. *Lamellar trama* regular, pale yellowish brown in mass, hyphae cylindric. *Pileipellis* a cutis of cylindric to inflated hyphae, up to 20 µm diam, incrusted, "Tawny" to "Ochraceous-Tawny" in mass. *Clamps* present. Fig. 6.

Specimens examined: **SOUTH AUSTRALIA.** Holotype, near Adelaide, Hope Valley, on sandy soil, 29.iv.1923,. *J.B. Cleland* (AD 12226).

Notes: *Inocybe exigua* is a small species with a cinnamon brown, finely-fibrillose pileus, a pallid stipe that is likely pruinose, prominently gibbous spores, and generally thin-walled or only slightly thick-walled, saccate, short pleurocystidia. Cleland did not mention the presence of a bulb at the stipe base, as was done for *I. emergens* and *I. calopedes*.

7. *Inocybe fibrillosibrunnea* Miller & Hilton, *Sydowia* 39: 132 (1987)

[Protologue] *Pileus* 14–21 mm broad, convex, convex-umbonate, brown to dark brown, "Verona Brown" to "Snuff Brown", dry, matted fibrillose tufts of light tipped fibrils over the disc somewhat recurved, irregularly raised over the margin, odor not distinctive. *Lamellae* subdistant to distant, adnate, alternate with long *lamellulae*, minutely fimbriate, white margins, light brown, "Sayal Brown". Stipe 10–37 mm long, (1–) 2.5–

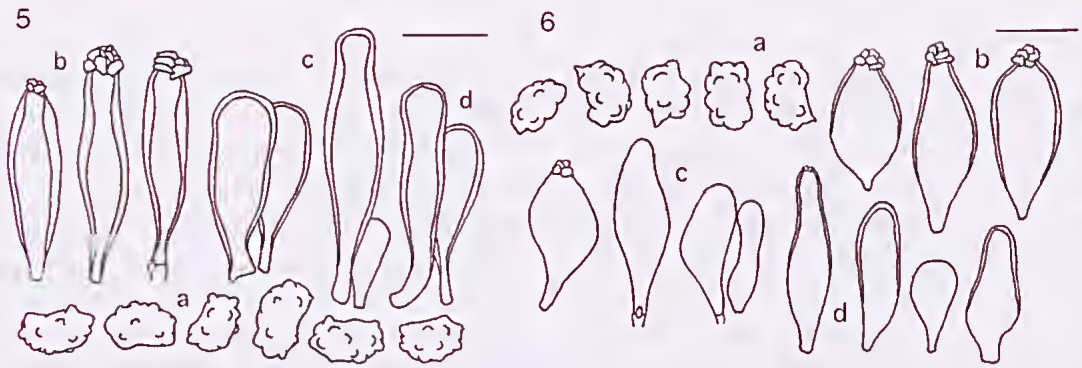


Figure. 5: *Inocybe emergens* (AD40426, lectotype of *Astrosporina emergens*): a. spores; b. pleurocystidia. c. caulocystidia from stipe apex; d. caulocystidia above stipe base. Scale bar = 10 µm for spores, 25 µm for other cells.

Figure. 6: *Inocybe exigua* (AD12226, holotype of *Astrosporina exigua*): a. spores; b. pleurocystidia; c. caulocystidia from stipe apex; d. caulocystidia above stipe base. Scale bar = 10 µm for spores, 25 µm for other cells.

3.5 mm broad usually enlarging somewhat at the apex and base, dry, coarsely pubescent with tufts of minute fibrils over the base in age, concolorous with the *pileus* or somewhat lighter, "Sayal Brown" to "Snuff Brown", veil cortinate, scanty, light brown, soon disappears with no annular zone.

Basidiospores (8.0–) 8.5–10.5 (–12.0) × (4.5–) 5.0–6.0 (–6.5) µm (n=27), spores from lamellar mounts reach up to 12.0 µm in length, smooth, amygdaliform with bluntly pointed apices, not reniform but at times with a suprahilar depression, with a distinct apiculus and slightly thickened wall, yellowish brown. *Basidia* 26–30 × 8–10 µm, 4-sterigmate, clavate, hyaline. *Pleurocystidia* 70–112 × 11–20 µm, lageniform with long cylindric to tapered necks, thick-walled, walls 2.5–4.0 µm thick, (pale) yellow in KOH, with a short basal pedicel; apices obtuse, sparsely crystalliferous; abundant. *Cheilocystidia* similar to pleurocystidia but shorter, frequent, paracystidia clavate, thin-walled, hyaline. *Stipitipellis* with dense clusters of caulocystidia similar to pleurocystidia at apex of stipe, at times with lanceolate necks, mixed with smaller cells of intermediate size and shape—mostly cylindric, occasionally fusiform or clavate, thin- or thick-walled, hyaline, intergrading with caulocystidioid hairs stemming from vestiture hyphae just below the apex; caulocystidioid hairs usually filiform, thick-walled, continuing down to base of stipe. *Pileipellis* a cutis of regular hyphae giving rise to ascending broad fascicles of hyphae, these cylindric to inflated, 5–28 µm diam, thin- or with slightly thickened walls, brown pigmented in mass, incrusting pigments very faint; terminal cells filiform to cylindric, thin- to thick-walled, often flexuous and tapered distally. *Clamps* present. Fig. 7.

Specimens examined: **WESTERN AUSTRALIA.** Holotype, 31.vii.1977, *Dell*, on ground under *Eucalyptus marginata* and *E. calophylla* (Myrtaceae), NW swamp, 10 km E of Kalamunda, Western Australia (PERTH 00777234 (UWA 2204)).

Notes: The gross morphological description is taken from Miller and Hilton (1987), while microscopic observations are our own. *Inocybe fibrillosibrunnea* is characterised microscopically by the very long, lageniform, yellow pleurocystidia; apex of stipe with caulocystidia soon integrading with caulocystidioid hairs, the latter descending to the base of the stipe; and amygdaliform spores mostly 8.5–10.5 × 5.0–6.0 µm. The spores may have a suprahilar depression, which probably led to Miller and Hilton to describe the spores as reniform. Macroscopically, this is a species with a brown or umbrinous pileus that is matted fibrillose-squamulose with tips slightly recurved on the disc. The stipe appears coarsely-fibrillose with scattered tufts of fibrils.

8. *Inocybe fulvo-olivacea* Cleland, *Trans. Roy. Soc. S. Aust.*: 57: 192 (1933)

[Protologue and AD 40427] *Pileus 1.2 cm, perconvexus (magis minusve), subfibrillosus, fulvo-olivaceus. Lamellae*

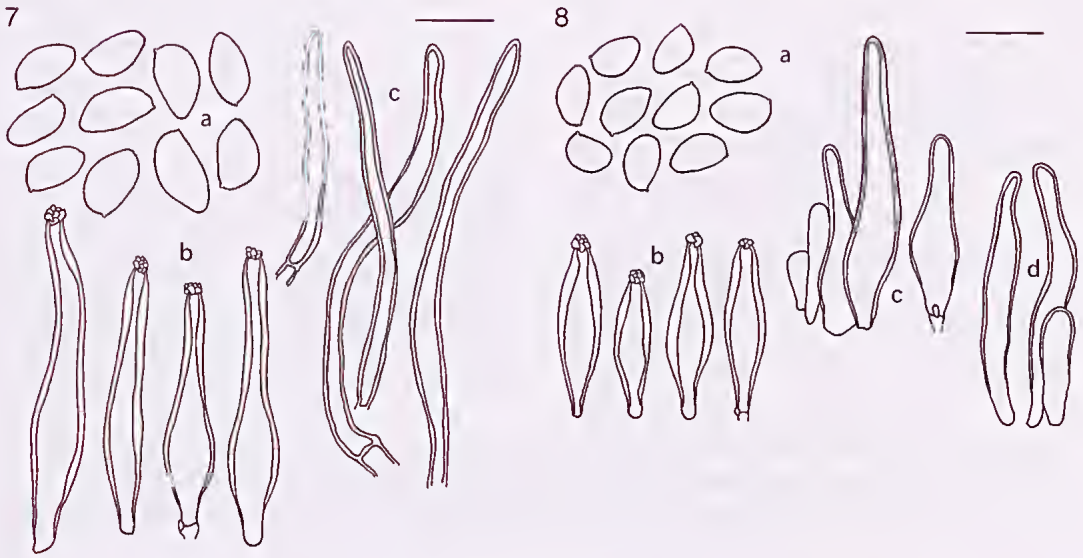


Figure. 7: *Inocybe fibrillosibrunnea* (PERTH00777234, holotype): a. spores; b. pleurocystidia; c. caulocystidioid hairs from throughout the stipe. Scale bar = 10 µm for spores, 25 µm for other cells.
Figure. 8: *Inocybe fulvo-olivaceae* (AD40427, lectotype): a. spores; b. pleurocystidia; c. caulocystidia from stipe apex; d. caulocystidioid hairs from stipe centre. Scale bar = 10 µm for spores, 25 µm for other cells.

adnatae, ascendentes, subconfertae, pallidiores quam "Saccardo's Umber". Stipes 2.5 cm, tenuis, granulosus, subcavus, pallido-brunneus, saepe supra subroseus. Sporae subtriangulares, perobliquae, 6.5–7 × 4 µm. Cystidia subventricosa, 45–65 × 15–17 µm. Belair, South Australia, August.

Basidiospores 6.5–7.5 (–8.0) × 4.5–5.5 µm (n=20), smooth, broadly amygdaliform to elliptic, mostly with (sub)conical apices, thick-walled, with a distinct apiculus, yellowish brown. *Basidia* 23–27 × 7–9 µm, 4-sterigmate, clavate, hyaline to pale yellowish, often collapsed. *Pleurocystidia* 48–70 × 10–15 µm, fusiform to slenderly fusiform, thick-walled, walls 2.5–4.0 µm thick, hyaline or pale yellowish, with no necks or short ones, at times merely tapered upwards, with a basal pedicel; apices obtuse, crystalliferous. *Cheilocystidia* simlar to pleurocystidia, paracystidia not studied. *Lamellar trama* regular, pale yellowish in mass, hyphae cylindric to inflated, up to 18 µm diam. *Caulocystidia* metuloid, fusiform to cylindric or irregularly cylindric, also lageniform, somewhat longer, 60–90 × 12–17 µm, at times with distinct necks, descending at least to the centre of the stipe, mixed with few cylindrico-clavate to clavate, thin-walled cells; base of stipe with vestiture of interwoven cylindric hyphae. *Pileipellis* a cutis, poorly reviving. *Clamps* present. Fig. 8.

***Specimens examined*: SOUTH AUSTRALIA.** Lectotype here designated, Belair, on ground, 4.viii.1928, *J.B. Cleland* (AD 40427 (=ADW 12681)).

Notes: AD 40427 contains several specimens in satisfactory condition and notes that are without doubt the source for the protologue of *I. fulvo-olivacea*. The corresponding material does not deviate from the protolgue, thus, we designate AD 40427 as the lectotype. Horak (1980) was unable to locate this material. Grgurinovic (1997), however, supplied Cleland's handwritten notes but did not study the collection. *Inocybe fulvo-olivacea* is characterised by its "Tawny-Olive" [per Cleland] finely-fibrillose pileus; small size; slender, pallid brownish stipe flushed with pink above that is at least pruinose on the upper half; small broadly amygdaliform to elliptic spores; and medium-sized thick-walled fusiform pleurocystidia. The collection appears similar to AD 5436 and AD 5437 determined by Cleland as *I. serrata* differing by a pale grayish brown or a pale yellowish brown pileus and without mention of rose tints on the stipe.

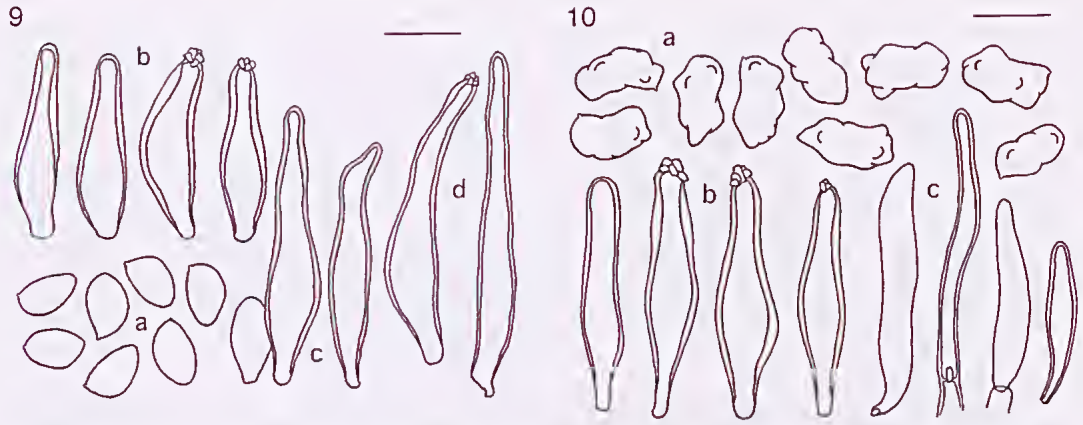


Figure. 9: *Inocybe granulosipes* (AD5450, lectotype): a. spores; b. pleurocystidia; c. caulocystidia from stipe apex; d. caulocystidioid hairs from stipe centre. Scale bar = 10 µm for spores, 25 µm for other cells.

Figure. 10: *Inocybe imbricata* (AD12227, holotype): a. spores; b. pleurocystidia; c. caulocystidioid hairs from stipe apex. Scale bar = 10 µm for spores, 25 µm for other cells.

9. *Inocybe granulosipes* Cleland, *Trans. Roy. Soc. S. Aust.* 57: 192 (1933)

[Protologue and AD 5450] *Pileus 1.2–1.8 cm, convexus, umbonatus, fibrillosus, tabacino-brunneus ad "Bister". Lamellae adnatae, subconfertae, subventricosae, tabacino-brunneae. Stipes 1.8–2.5 cm, subtenuis, e farcto subcavus, aequalis, sub-bulbosus, "Bister" granulis albidis farinaceis vel fibrillosis. Caro pertenuis. Sporae obliquae, 8.5 × 5 µm. Cystidia inflata ad angusto-fusiformia, 45 × 19 µm, 50 × 9 µm. Plantae gregariosae. Stirling West, Mount Lofty, South Australia, July.*

Basidiospores (7.0–) 7.5–8.5 × (4.5–) 5.0–5.5 µm (n=20), smooth, subamygdaliform or broadly so to elliptic with pointed or rounded apices, with slightly thickened wall and small but distinct apiculus, yellowish brown. *Basidia* 26–33 × 7–8 µm, 4-sterigmate, clavate, hyaline. *Pleurocystidia* 55–75 × 10–15 µm, slenderly fusiform, less often or rarely lageniform, thick-walled, walls 2.5–4.0 µm thick, pale yellow or hyaline, with distinct necks and basal pedicel; apices obtuse, crystalliferous. *Cheilocystidia* not studied. *Stipitipellis* with dense clusters of caulocystidioid cells at apex of stipe, these 83–125 × 9–13 µm, and cells of intermediate shape and size—mostly fusiform to subcylindric or irregularly cylindric but thick-walled—descending to the centre of the stipe, flexuous; vestiture hyphae interwoven and more conspicuous at the base of the stipe with infrequent caulocystidioid terminal cells. *Lamellar trama* regular, subhyaline to pale yellowish brown, hyphae cylindric, up to 13 µm diam. *Pileipellis* a cutis of repent hyphae, these cylindric to inflated, up to 23 µm diam, faintly incrusted and with thin to slightly thickened walls; surmounted by broad, smooth, thin-walled hyphae 4–16 µm diam. *Clamps* present. Fig. 9.

Specimens examined: **SOUTH AUSTRALIA.** Lectotype here designated, Stirling West, gregarious, 23.vi.1927, *J.B. Cleland* (AD 5450); Mt. Lofty, on ground, 7.iv.1917, *J.B. Cleland* (AD 5451) (not *I. granulosipes*).

Notes: The collection AD 5450 is designated here as the lectotype of *I. granulosipes* since it is the collection from which the protologue is clearly drawn. It consists of numerous specimens in satisfactory condition. Contrary to Horak (1980) *I. granulosipes* is not the same species as *I. australiensis*. Horak did study AD 5450 (as ADW 12719) and obviously drew his conclusions based on a number of microscopic similarities, namely spore and cystidial characters. However, side-by-side comparison of the types indicates dissimilarities in the surface of the pileus. *Inocybe australiensis* possesses a very dark brown, squarrose to squamulose or scaly pileus; *I. granulosipes* has a merely fibrillose dark brown to brown or umbrinous pileus. As pointed out by Grgurinovic (1997), AD 5451 collected at Mt. Lofty in 1917, although determined by Cleland as *I. granulosipes*, is not conspecific with the lectotype.

10. *Inocybe imbricata* (Cleland) Garrido, *Bibloth. Mycol.* 120: 176 (1988)

Astrosporina imbricata Cleland, *Trans. Roy. Soc. S. Aust.*: 57: 192 (1933).

[Protologue] *Pileus ad 16 mm, convexus vel subconico-campanulatus, fibrillis adpressis umbricatis [sic], fusco-brunneus. Lamellae adnatae, deinde secedentes, subconfertae, subventricosae, fusco-brunneae. Stipes 16 mm, subtenuis, aequalis, infarctus, fibrillosus, pallido-brunneus. Caro pilei pallida, stipis sub-brunnea. Sporae angulatae, 9–11 × 5.5 µm. Kinchina, South Australia, June.*

Basidiospores (9.0–) 9.5–11.0 (–11.5) × 5.5–6.5 µm (n=20), oblong-angular with 5–8 inconspicuous nodules, at times these merely corners, around a rectangular to trapeziform outline, usually with a conical apical nodule, at times one side with a concave depression, yellowish brown, not reacting with Melzer's. *Basidia* 30–42 × 7–10 µm, 4-sterigmate, clavate, hyaline to pale ochraceous. *Pleurocystidia* 58–76 × 11–17 µm, fusiform or slenderly so to subcylindric, thick-walled, walls 2.0–3.0 µm thick, hyaline, usually with a distinct neck and slender basal pedicel; apices obtuse and lacking crystals. *Cheilocystidia* similar to pleurocystidia, often shorter, at times ochraceous. *Stipitipellis* with scattered cystidioid end cells at the apex, these generally cylindric or fusiform and thin-walled, cauloparacystidia not observed; centre of stipe with interwoven vestiture hyphae terminating in caulocystidioid hairs, vestiture hyphae descending to base of stipe. *Lamellar trama* regular, light yellowish brown in mass, hyphae cylindric to inflated, up to 15 µm diam. *Pileipellis* a cutis giving rise to broad fascicles of somewhat ascending hyphae, these often inflated, up to 25 µm diam, end cells not differentiated, light reddish brown or "Tawny" pigmented in mass, walls thin or slightly thickened, incrustations not evident. *Clamps* present. Fig. 10.

***Specimens examined*: SOUTH AUSTRALIA.** Holotype, Kinchina, 8.vi.1925, leg. *J.B. Cleland* (AD 12227); AD 5439 (=AD 12673B, originally mixed with *I. murrayana* AD 5440, on ground, Kinchina, 8.vi.1925, leg. *J.B. Cleland*).

Notes: *Inocybe imbricata* is distinct by virtue of its small size; dark brown, shaggy-squamulose pileus; fibrillose, pale brownish even stipe; thick-walled, fusiform to cylindric pleurocystidia; and oblong-angular spores with few indistinct nodules and corners. The spores are unusual in that they possess a concave depression on one side. We agree with Grgurinovic (1997) that the lectotype of *I. murrayana* Cleland is not a synonym of *I. imbricata*.

11. *Inocybe murrayana* Cleland, *Trans. Roy. Soc. S. Aust.* 57: 192 (1933)

[Protologue] *Pileus ad 1.6 cm, conicus, deinde expansus, umbonatus magis minusve, subtili-fibrillosus vel fibrilloso-squamosus, sericeo-nitidus, cinnamoneo-brunneus vel "Buckthorn Brown" vel "Dresden Brown" vel russus. Lamellae adnatae vel adnexae, subconfertae, marginibus subserratis, tabacino-brunneus vel avellaneus. Stipes 2.5 cm, aequalis, subtili-striatus vel fibrillosus vel farinaceus, solidus, tabacino-brunneus vel brunneo-pallidus. Sporae obliquae, pallido-brunneae, 9–11–13 × 5.2–5.5 µm. Cystidia acuminata basi inflata vel ventricosa, 85 × 11 µm. South Australia, Kinchina, August.*

Basidiospores (9.0–) 9.5–11.5 (–12.0) × (4.5–) 5.0–6.0 µm (n=20), mostly 10.0–11.0 × 5.0–5.5 µm, smooth, amygdaliform, at times oblong-amygdaliform, with conical apices, slightly thick-walled, with a small but distinct apiculus, yellowish brown, unreactive in Melzer's. *Basidia* about 28 × 9 µm, 4-sterigmate. *Pleurocystidia* 65–77 × 11–18 µm, slenderly fusiform, fusiform, or lageniform, thick-walled, walls 2.0-3.0 µm thick, hyaline; with elongated necks and short tapered pedicel; apices obtuse, often crystalliferous; frequent. *Cheilocystidia* similar to pleurocystidia, at times yellowish, scattered among hyaline, thin-walled, clavate paracystidia; abundant. *Caulocystidia* similar to pleurocystidia but often lageniform with lanceolate necks and subacute apices, mixed with cauloparacystidia, together forming scattered clusters at the apex and below the centre of the stipe; base with metuloidal cystidia but cauloparacystidia not observed. *Lamellar trama* regular, pale ochraceous in mass, hyphae cylindric, up to 15 µm diam. *Pileipellis* a cutis of russet brown to reddish brown hyphae in mass, these cylindric, 6–15 µm diam, thin-walled or slightly thickened, incrusted. *Clamps* present. Fig. 11.

***Specimens examined*: SOUTH AUSTRALIA.** Lectotype, Kinchina, 1 August 1925, *J.B. Cleland* (AD 5441); Kinchina,

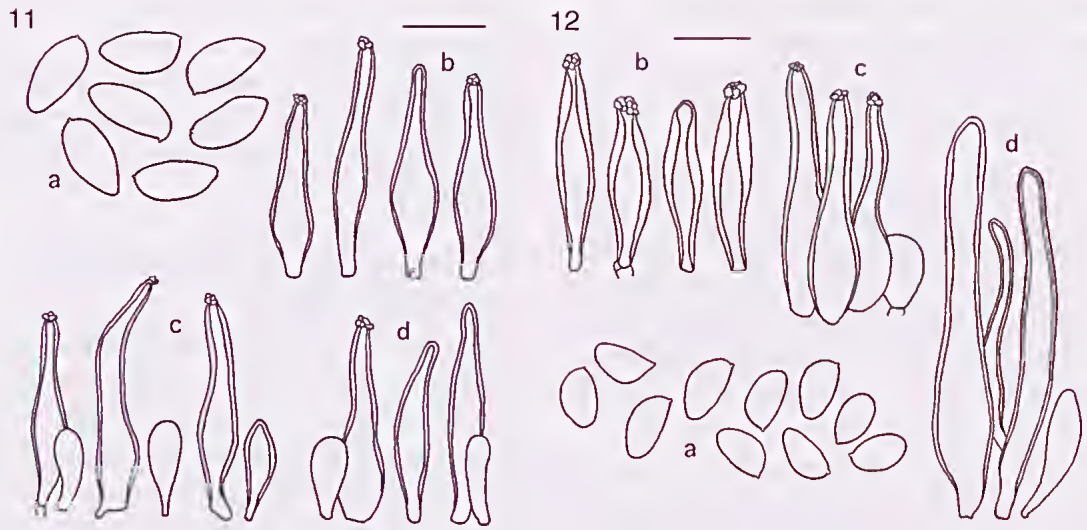


Figure. 11: *Inocybe murrayana* (AD5441, lectotype): a. spores; b. pleurocystidia; c. caulocystidia from stipe apex; d. caulocystidia above stipe base. Scale bar = 10 µm for spores, 25 µm for other cells.
Figure. 12: *Inocybe serrata* (AD5438, lectotype): a. spores; b. pleurocystidia; c. caulocystidia from stipe apex; d. caulocystidioid hairs from stipe centre. Scale bar = 10 µm for spores, 25 µm for other cells.

8.vi.1925, *J.B. Cleland*; AD 5442, Monarto South, Kinchina, 9.vii.1922, *J.B. Cleland* (AD 5440 p. p.) (doubtfully *murrayana*).

Notes: *Inocybe murrayana* has a somewhat confusing taxonomic history. Horak (1979) considered AD 5440 (=ADW 12673) as the holotype and found the material conspecific with *I. imbricata* (as *Astrosporina imbricata*). Evidently, only a portion of the type was studied because Grgurinovic (1977) found AD 5440 to be heterogeneous with another portion representative of *I. murrayana*, and consequently selected AD 5441 as the lectotype. The lectotype contains several specimens in adequate condition, and we concur that a portion of AD 5440 is indeed similar to *I. murrayana* and consistent with the protologue, including Cleland's handwritten notes describing the collection and its occurrence.

Inocybe murrayana is a small species with a cinnamon brown or umbrinous ("Snuff Brown") pileus and similarly coloured stipe. The pileus at most reaches 2 cm in diameter and often is fibrillose or with a matted fibrillose-squamulose disc (AD 5442). The stipe is generally up to 2.5 cm long, slender, without a bulb, brown to pale brown, and is pruinose at least down to the centre of the stipe. Microscopically, *I. murrayana* is distinctive due to the long amygdaliform or oblong-amygdaliform shaped spores that are mostly 10.0–11.0 × 5.0–5.5 µm; and caulocystidia or caulocystidioid cells with lanceolate necks mixed with other caulocystidioid elements of intermediate shape and size descending to at least the centre of the stipe.

AD 5442 is unusual due to the matted fibrillose-squamulose centre of the pileus and pleurocystidia with yellow walls. This collection would suggest a close relationship with *I. fibrillosibrunnea* Miller & Hilton, which differs by the longer pleurocystidia.

12. *Inocybe serrata* Cleland, *Trans. Roy. Soc. S. Aust.* 57: 192 (1933)

[Protologue] *Pileus 1.2 cm, convexus, fibrillosus, Verona-brunneus vel pallido-brunneus. Lamellae adnatae, marginibus serratis et interdum pallidioribus, tabacino-brunneae vel ligno-brunneae. Stipes 1.8–3.0 cm, tenuis, attenuatus, fibrillosus, approxime "Warm Buff", basibus villosis. Caro firma, in medio 1 cm lata, farinaceus, pallido-bruneus. Sporae glabrae, obliquae, pallido-flavo-brunneae, 7.5–9 × 4.5–5 µm. Cystidia fusiformes vel ampulliformes, 27–56 × 11–13 µm. Plantae gregariosae vel subcaespitosae. Mount Lofty, Upper Tunkalilla Creek, South Australia, April–June.*

Basidiospores (6.0–) 6.5–9.0 (–9.5) × 4.5–5.5 µm (n=50/4), smooth, variable in shape—amygdaliform, broadly amygdaliform, to subtriangular in profile, or elliptic, without a suprahilar depression; apices bluntly pointed to rounded; with a small but distinct apiculus, thick-walled, yellowish brown. *Basidia* 23–30 × 7–8 µm, 4-sterigmate, clavate, hyaline. *Pleurocystidio* 53–75 × 11–15 µm, fusiform, thick-walled, walls up to 4.0 µm thick, hyaline or pale yellowish, with necks or merely tapered above to obtuse, crystalliferous apices, with a basal pedicel, frequent. *Cheilocystidia* not studied. *Coulocystidio* often lageniform, also fusiform, thick-walled and with crystalliferous apices, 83–110 × 14–18 µm, descending to at least the centre of the stipe mixed with cauloparacystidia and intermediate cells of varying shape and size, intergrading with caulocystidioid hairs at least by the centre of the stipe; lower part of stipe composed of interwoven vestiture hyphae with few cystidioid end cells. *Lomellor tromo* not studied. *Pileipellis* a cutis of lightly incrusted hyphae, up to 20 µm diam, "Ochraceous-Tawny" in mass, thin- to slightly thick-walled, surmounted by an interwoven layer of smooth, thin-walled, hyaline superficial hyphae, up to 15 µm diam. *Clomps* present. Fig. 12.

***Specimens examined*: SOUTH AUSTRALIA.** Mt. Lofty, 21.vi.1924, *J.B. Cleland* (AD 5438 (=ADW 12672)); Mt. Lofty, 7.iv.1917, on ground under log, *J.B. Cleland* (AD 5436 (=ADW 12670)); Mt. Lofty, 7.iv.1917, *J.B. Cleland* (AD 5437 (=ADW 12668)); lectotype here designated, Mt. Lofty, 2.vi.1928, *J.B. Cleland* (AD 5444 (=ADW 12669)). Upper Tunkalilla Creek, subcaespitose on ground, 4.vi.1930, *J.B. Cleland* (AD 5446 (=ADW 12667)), determination questionable.

***Notes*:** Horak (1980) cited ADW 12668 (=AD 5437) as the holotype, however, this cannot be the case given that Cleland's protologue was clearly derived from notes of ADW 12672 (=AD 5438). Hence, AD 5438 would be the proper collection to designate as the lectotype if not for its heterogeneous state, which contains both *Inocybe* and *Cortinorius* species. Even with the numerous *Cortinorius* basidiomes aside, it is not clear from the protologue that Cleland derived the macroscopic description from the *Inocybe* portion of the collection. Furthermore, the shape of the spores, a critical character in *Inocybe* taxonomy, varies among the remaining specimens. Some collections collected many years apart and determined by Cleland as *I. serroto* are inconsistent with each other, viz. AD 5446 (spores mostly 9.0–11.0 × 4.5–5.5 µm that possibly represents *I. murrayana* or *I. fibrillosibrunneo*). Here we designate AD 5444 as lectotype of *I. serrota*, the macroscopic notes of which include the following: pileus up to 1.3 cm diam, convex, fibrillose, pallid brown, colour of dead grass; lamellae adnate, "Wood Brown", edges finely serrate and white; stipe up to 3.0 cm long, slender, mealy fibrillose. Mt. Lofty, South Australia, 23 June 1928. Grgurinovic (1997) applied the name *I. australiensis* to *I. serroto*, but the former species differs by its dark brown and distinctly scaly pileus.

Excluded Taxa

Inocybe austrofibrillosa Grgurinovic, *Austral. Mycol.* 21: 35 (2002)

Cortinorius fibrillosus Cleland, *Trans. Roy. Soc. S. Aust.* 52: 222 (1928); *Inocybe fibrillosa* (Cleland) Grgurinovic, *Lorger Fungi of S. Aust.*: 190 (1997), *non Inocybe fibrillosa* Peck, *Ann. Rep. N.Y. St. Mus.* 41: 65 (1888).

Inocybe cystidiocotenoto Grgurinovic, *Lorger Fungi of S. Aust.*: 188 (1997); *Cortinorius cystidiocotenotus* (Grgurinovic) Gasparini, *Austrol. Mycol.* 25: 25 (2006).

[Protologue] *Pileus* 1 to 1 1/2 inches, deeply convex, then convex and gibbous, hoary from whitish mealy fibrils sometimes forming a white edge to the *pileus*, when moist reddish brown [near Russet (xv.) or darker], when dry between Cinnamon and Cinnamon Buff (xxix). *Gills* adnexed, moderately close, yellower than Ochraceous Tawny (xv.). *Stem* up to 1 3/4 inches (4.3 cm) high, slender, fibrillose, pallid whitish, hollow. Flesh reddish, thin. Spores pale brown, oblique 9 × 4.5 µm. Caespitose on the ground near stumps. Mt. Lofty, South Australia, June.

Bosidiospores (7.5–) 8.0–9.0 × 4.5–5.0 (–5.0) µm (n=20), smooth in appearance even in Melzer's reagent, elliptic to subamygdaliform with obtuse apices, noticeably pale—"Warm Buff" or yellowish (2.5Y 7/6) in KOH; reddish brown or "Tawny" viz., dextrinoid (near 2.5Y 4/6) in Melzer's; thick-walled, germ pore and plage absent, with a small but distinct apiculus. *Basidio* 22–28 × 6–8 µm, 4-sterigmate, clavate, mostly hyaline but at times ochraceous. *Pleurocystidio* absent. *Cheilocystidio* 17–21 × 14–15 µm, saccate to pyriform or broadly clavate, thin-walled, hyaline, difficult to revive but edges of lamellae are sterile under the stereomicroscope. *Caulocystidia* absent; vestiture

hyphae interwoven, often thick-walled at least from the lower part of the stipe, hyaline, cylindric, 4–12 µm diam. *Lamellar troma* regular, light "Tawny" or reddish brown pigmented in mass, hyphae cylindric to inflated, up to 25 µm diam. *Pileipellis* composed of a interwoven suprapellis or ascending layer of cylindric to inflated hyphae, these hyaline, thin- to thick-walled, walls up to 1.5(–2.0) µm thick; subpellis ochraceous pigmented in mass, hyphae primarily inflated, up to 20 µm diam, lightly incrusted. *Clomps* present.

***Specimens examined*: SOUTH AUSTRALIA**. Lectotype, Mt. Lofty, 23.vi.1928, *J.B. Cleland* (AD 4169); Morialta Falls, caespitose on burnt soil under *Eucalyptus* sp., 28.vi.1984, *C.A. Grgurinovic* (35684) & *R.E. Halling* (AD 12264), holotype of *Inocybe cystidiocatenata*.

***Notes*:** Given the presence of cheilocystidia and smooth pale brownish spores, Grgurinovic (1997) transferred this species to *Inocybe*. Later, realising *Inocybe fibrillosa* (Cleland) Grgurinovic was a homonym of *I. fibrilloso* Peck, a new name, *I. austrofibrillosa* Grgurinovic, was proposed (Grgurinovic 2002). Several lines of evidence, however, demonstrate that *I. austrofibrillosa* is not an *Inocybe*: the *Telamonio*-like habit, the absence of pleurocystidia but presence of a distinct apiculus on the spores, and the reddish brown colour or dextrinoid reaction of the spores in Melzer's. We consider Cleland's original generic disposition, *Cortinorius*, as the best placement of this unusual species despite the appearance of smooth spore walls, pale coloured spore deposit and spore wall reaction in Melzer's. The presence of cheilocystidia does not in itself exclude *Cortinorius* from consideration as a small number of species exhibit their presence; furthermore, pale pigmented spores that appear smooth under light microscopy, although highly unusual, can exceptionally be found in *Cortinorius*, e.g., *C. oureifolius* Peck.

Fresh material of this species, identified as *I. cystidiocatenoto* Grgurinovic, is not uncommon in Western Australia where a number of collections have been routinely documented. One of these (E6584 PERTH) was sequenced (AY333317 *rpb2*, AY380361 nLSU-rRNA, AY333306 *rpb1*: accessions at GenBank) and confirmed as closely related to other species of *Cortinorius* (Matheny & Ammirati 2003). There is little doubt that *I. cystidiocatenoto* is conspecific with *Cortinorius fibrillosus* after examination of both types, and that *C. fibrillosus*, the older name, has nomenclatural priority. Grgurinovic maintained their separation chiefly on cystidial characters, which we were unable to verify. Both types also share the thick-walled hyphae of the pileipellis and vestiture hyphae of the stipe. The spores of the type of *I. cystidiocatenota*, although largely unreactive in Melzer's, feature occasional spores that are dextrinoid. The following features stand out for this species: the bright brown gills and flesh (near 6C8), pale spores, and cheilocystidia of inflated elements in chains in a broad layer on the gill edge. Recently, *Inocybe cystidiocotenato* was recombined into *Cortinarius* by Gasparini (2006), but comparison to *C. fibrillosus* was not made, unfortunately. The species was included in a ribosomal RNA phylogeny of *Cortinorius* and placed in the *Obtusi* clade by Garnica et *al.* (2005). A macroscopic description and illustrations (Pl. 8a and Pl. 29c) can be found in Grgurinovic (1997) and Gasparini (2006). For completeness our microscopic observations of the type of *I. cystidiocotenato* are as follows:

Basidiospores 8.0–9.0 (–10.5) × 5.0–5.5 µm (n=20), elliptic to subamygdaliform with mostly obtuse apices, smooth in KOH and Melzer's, noticeably quite pale in KOH—very pale brown or "Warm Buff", mostly not changing colour in Melzer's but occasional spores dextrinoid, with thick wall and a small but distinct apiculus, germ pore and plage absent. *Bosidia* 25–31 × 6–8 µm, 4-sterigmate, clavate, hyaline or occasionally ochraceous, not necropigmented. *Pleurocystidia* absent. *Cheilocystidio* elliptic or saccate, quite small but as depicted by the type line drawings (Grgurinovic 1997) in relation to the size of the basidia. *Coulocystidia* absent; stipe sheathed by vestiture hyphae, these interwoven, filiform, smooth, usually thick-walled, similar to those of the suprapellis on the pileus; terminal cells undifferentiated; stipe hyphae pale ochraceous in mass. *Lomellor tromo* regular, bright cinnamon pigmented in mass, hyphae cylindric to inflated, up to 25 µm diam, incrusted. *Clomps* present.

Inocybe gigaspora (Cooke & Massee) McAlpine, *Syst. Arr. Austral. Fungi*: 22 (1895)

Agoricus gigosporus Cooke & Massee in Cooke, *Grevilleo* 18: 3 (1889); *Hebeloma gigosporum* (Cooke & Massee) Sacc., *Syll. Fung.* 9: 102 (1891); *Phoeomorosmius*

gigasporus (Cooke & Massee) Pegler, *Austral. J. Bot.* 13: 333 (1965)

Pegler (1965) examined the type held at Kew and recorded 2-sterigmate basidia, absence of pleurocystidia, and large, smooth, deep ferruginous spores (16–19 × 9–11 µm). A combination in *Phaeomarasmius* was proposed. What Pegler neglected to add was that the spores contain a broad conspicuous germ pore, which is noticeable in his fig. 5/13a. Because of the pronounced germ pore recorded by Pegler, the disposition of *Agaricus gigasporus* resides outside the Inocybaceae. No new information was added by Horak (1980).

Inocybe gomphodes (Kalchbr.) Sacc., *Syll. Fung.* 5: 786 (1887)

Agaricus gomphodes Kalchbr., *Grevillea* 8: 152 (1880)

Pegler (1965) and Horak (1980) examined the type at Kew, and both concurred with the exclusion of this species from *Inocybe* given the dextrinoid spores with a germ pore and the poor fragmentary condition of the type. We have no new information to add.

Inocybe marangania Grgurinovic, *Larger Fungi of S. Austral.*: 179 (1997) Fig. 13

For the macroscopic description, see Grgurinovic (1997).

Basidiospores 7.0–8.0 × 4.0–5.0 µm (n=15), smooth, (sub)amygdaliform, not phaseoliform, with conical apices in profile; apices with an indistinct germ pore; "Tawny" or "Hazel" in KOH, thick-walled, walls up to 0.4 µm thick, with an indistinct apiculus, not reacting in Melzer's. *Basidia* 20–27 × 6–7 µm, 4-sterigmate, cylindrico-clavate to cylindric, hyaline or ochraceous. *Pleurocystidia* 43–80 × 10–14 µm, mostly lageniform with elongated cylindric necks, apices obtuse or at times swollen or subacute, not capitate; intermediate shapes also observed that are tapered distally, thin-walled, apices not crystalliferous but necks may be granular incrusted, hyaline or ochraceous or with vacuolated portions with yellow contents. *Cheilocystidia* 28–55 × 10–14 µm, a few similar to pleurocystidia, but mostly fusiform or broadly so that are merely tapered distally to an obtuse apex, thin-walled, hyaline or ochraceous, paracystidia not observed. Extreme apex of stipe with clusters of caulocystidia, usually cylindric and

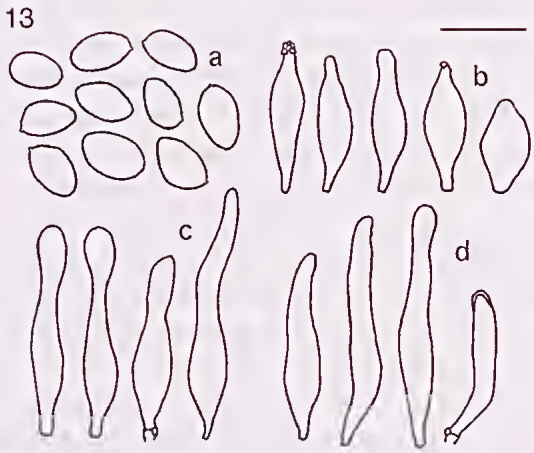


Figure. 13: *Pholiota marangania* (AD12263, holotype of *Inocybe marangania*): a. spores; b. cheilocystidia; c. pleurocystidia; d. caulocystidia from stipe apex. Scale bar = 10 µm for spores, 25 µm for other cells.

bright ochraceous to hyaline or parts of the cells with ochraceous contents; bright tawny refractive hyphae frequent in stipe trama. *Lamellar trama* regular, pale yellowish in mass, hyphae cylindric, up to 16 µm diam. *Pileipellis* an ixocutis of loosely interwoven hyphae, these narrowly cylindric, 2.5–4.0 µm diam, often branching, ochraceous or yellowish to subhyaline, thin-walled; subpellis a bright ochraceous-tawny repent layer in mass, hyphae cylindric to inflated, 5–22 µm diam, incrusted with pigment. *Clamps* present.

***Specimens examined*: SOUTH AUSTRALIA.** Holotype, Mt. Lofty Botanic Gardens below "Carmino", gregarious in troops among *Funaria*, 9.v.1984, *C.A. Grgurinovic* 2A584 & *R.J. Chinnock* (AD 12263).

***Notes*:** The presence of a gelatinised pileipellis, an indistinct germ pore, and what appears to be growth on a charred substrate indicate *Inocybe marangania* is a species of *Pholiota*, likely related to the *P. highlandensis* group. Thus, the new combination is proposed: *Pholiota marangania* (Grgurinovic) Matheny & Bougher, comb. nov. *Inocybe marangania* Grgurinovic, *Larger Fungi of S. Austral.*: 179 (1997) (basionym).

Inocybe striatula (Cleland) Grgurinovic, *Larger Fungi S. Austral.*: 190 (1997)

Cortinarius striatulus Cleland, *Trans. Roy. Soc. S. Austral.* 52: 221 (1928).

[Protologue] *Pileus* up to 1 in. (2.5 cm), somewhat convex to nearly plane, more or less gibbous, wavy on the margin, sometimes slightly repand, very finely fibrillose, submembranaceous, when moist striate at the periphery and between Russet and Cinnamon Brown (xv.), with a pale ring around the edge, when dry paler than Cinnamon Buff (xxix.). *Gills* sinuate, moderately close, slightly ventricose, near Sayal Brown (xxix.), with narrow finely serrate whitish edges. *Stem* 2 ins. (5 cm) high, moderately slender, a little flexuous, sometimes flattened, attenuated at the base and sometimes at the apex as well, fibrillose, markedly hollow, pallid, with a brownish tint above. Flesh pallid with a slight reddish-brown tint. Spores yellow-brown, oblique, 7.5 × 4 µm, subcaespitose amongst shrubs under Eucalypts. S.A.—Mt. Lofty, July 28, 1928.

Basidiospores 7.0–8.5 × (4.0) 4.5–5.5 µm (n=20), faintly verrucose in Melzer's, elliptic to subamygdaliform with obtuse or bluntly pointed apices, germ pore absent; "Light Ochraceous Buff" or "Ochraceous Buff" in KOH, thick-walled, with a small but distinct apiculus, not reacting in Melzer's. *Basidia* 22–26 × 6–7 µm, 4-sterigmate, cylindrico-clavate to clavate, hyaline to ochraceous, many collapsed. *Pleurocystidia* none. *Cheilocystidia* not demonstrable with confidence. *Caulocystidia* absent, stipe surface with sparse layer of vestiture hyphae at apex down to the base, similar to suprapellis hyphae described below. *Lamellar trama* regular, "Ochraceous-Buff" to hyaline in mass, not brightly pigmented, hyphae cylindric, up to 13 µm diam. *Pileipellis* with a suprapellis composed of an interwoven layer of narrowly cylindric, smooth, thin-walled, hyaline hyphae, these up to 7.0 µm diam, mostly collapsed; subpellis, "Ochraceous-Tawny" pigmented and composed of mostly inflated hyphae, up to 27 µm diam, faintly incrusted. *Clamps* present.

***Specimens examined*: SOUTH AUSTRALIA.** Holotype, Mt. Lofty, 28.vii.1928, *J.B. Cleland* (AD 4660); Waterfall Gully, 1.vii.1945, *J.B. Cleland* (AD 4656); Belair National Park, 11.viii.1945, *J.B. Cleland* (AD4655).

Notes: This is *Cortinarius striatulus* and should be recognised as such as originally proposed by Cleland. The spores are faintly verrucose, possess a distinct apiculus, and the holotype and other authentic materials display a *Telamonia*-like habit, including the downwards attenuated stipe and striate pileus carefully emphasized in the protologue. Fresh material of what we interpret to represent this species (E6783 (=PBM 2137), PERTH, Plantagenet, 24 June 2001, *P.B. Matheny*) demonstrates the presence of globose, pyriform to subcylindric small cheilocystidia (16–40 × 15–24 µm) and the other characters enumerated above.

Inocybe victoriae (Cooke & Massee) Sacc., *Syll. Fung.* 9: 101 (1891)

Agaricus victoriae Cooke & Massee in Cooke, *Grevillea* 16: 72 (1888); *Hebeloma victoriae* (Cooke & Massee) Pegler, *Austral. J. Bot.* 13: 347 (1965)

Pegler (1965) transferred *Inocybe victoriae* to *Hebeloma* given the brown spores and gelatinized pileipellis. Horak (1980) commented on the poor condition of the type, and that it may represent a species of *Lepiota* given smooth, pale yellow, and slightly dextrinoid spores. We have no new information to report on this species, other than it should not be confused with *Hebeloma victoriense* A.A. Holland & Pegler.

Doubtful taxa

Inocybe albidipes Cleland & Cheel, *Transactions of the Royal Society of South Australia* 42: 107 (1918)

The type specimens of *I. albidipes* have yet to be located although a watercolour is extant per Horak (1980). The protologue describes a species with nodulose spores, stipe with a swollen to marginate bulb, and light to yellowish-brown fibrillose and rimose pileus with an acute umbo when young. The stipe would be white given Cleland's choice of specific epithet. This description would suggest an affinity with north temperate taxa such as *I. mixtilis* (Britz.) Sacc. or *I. praetervisa* Quél. Until we can examine the watercolour, we consider the species doubtful.

Inocybe brunnea K. Syme, Survey Larger Fungi Two Peoples Bay Nature Reserve 14 (1992), nom. inval., Art. 36.1

The name appears in a report and is a *nomen nudum* with no Latin description (May and Wood 1997) or any accompanying description. The name should not be confused with *I. brunnea* Quél.

Inocybe crassipes (Cooke & Massee) Pegler, *Austr. J. Bot.* 13: 342 (1965)

Agaricus ozes var. *crassipes* Cooke & Mass., Grevillea 15: 93 (1887); *Collybia ozes* (Fr.) Quél. var. *crassipes* (Cooke & Mass.) Sacc., Syll. Fung. 9: 34 (1891)

Grgurinovic (1997) presents a statement made by Pegler (1965), who studied type material at Kew and considered the species in section *Rimosae*. We concur with Horak (1980) that *I. crassipes* is best regarded as doubtful given its fragmentary state and lack of data on cheilocystidia. The lead author was able to view a copy of a painting of the holotype of *Agaricus ozes* var. *crassipes* held at MEL. The icon features a pileus that is dark reddish brown, somewhat rimose with a few tears along the margin, more or less avellaneous to fawn coloured lamellae that are medium in breadth with darker pigmented edges, and a dark reddish brown stipe that is fibrillose-striate and enlarged towards the base. No other critical diagnostic features are discernible. In our opinion, it could be consistent with a member of section *Rimosae*, but the darker lamellar edges would be unusual for this group. The rather somber colours and darker lamellar edges could also point to *Auritella*, but without complete microscopic data, it is not possible to apply the name at this point.

Inocybe subasterospora Cleland & Cheel, *Trans. Roy. Soc. S. Aust.* 42: 106 (1918)

Type material was not located at AD. However, two watercolour icons are referenced in the protologue (below), which we have not seen. Cleland & Cheel (1918) state the species is common in the Sydney district, so it would seem likely material corresponding to the following description may be encountered:

[Description from protologue] Pileus occasionally up to 1 1/4 inch in diameter, slightly convex, sometimes depressed, subgibbous to occasionally papillately umbonate, dark brown, occasionally lighter or rusty-brown and often more chestnut at the periphery, usually fibrously streaked and splitting, occasionally more scaly. Gills adnate to adnexed, separating from the stem, moderately crowded, pale milk-coffee coloured, then cinnamon, sometimes with a white edge. Stem up to 1 1/2 inches high, moderately stout, solid, slightly fibrillose, pale brownish, slightly mealy above, base sometimes a little swollen. Spores irregularly knobby, 7-9 × 5.2-7 µm. Cystidia numerous, ventricose, apices usually knobby, 42 × 17, 47 × 15.5, 50 × 14, 55 × 21.5, 70 × 17 µm, etc.

Sydney district, March to July, October, December; Pittwater, April, Parramatta, July; Milson Island, Hawkesbury River, July, November; Hill Top (E. C.), May; localities not noted (several); locality not stated (stem white but cap dark). (Miss Clarke, Watercolour No. 33; D.I.C., Watercolour No. 63; Herb., J.B.C., Form. Sp., November, 1914).

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Kelita (Amaranthaceae), a new genus from Queensland, Australia

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Introduction

Amaranthaceae is well represented in Australia. The largest genera are *Ptilotus* R.Br. (c. 100 species), *Gomphrena* L. (31 indigenous species), *Amaranthus* L. (11 indigenous species) and *Alternanthera* L. (c. 6 indigenous species). There is no recent revisionary account for *Ptilotus* or *Alternanthera*, but *Gomphrena* (Palmer 1998) and *Amaranthus* (Palmer 2009) have recent treatments for Australian species. There are only three existing endemic Australian genera, namely *Hemichroa* R.Br. (3 species), *Nyssanthes* R.Br. (2 species) and the recently named monotypic genus *Omegandra* G.J. Leach & C.C. Towns.

The genus described here belongs to the Subfamily Amaranthoideae (based on the bilocular anthers), and the Subtribe Aervinae Endl. (based on the pendulous ovule). It is closely allied to both *Ptilotus* and *Omegandra*. Some of the distinctive features of the new genus are the denticulate leaves, the zygomorphic flowers and the uncinate awns present on all tepals.

Townsend (1993) provided an excellent synopsis of the family worldwide, including a brief description of all genera, a key to the genera, and a discussion of the major characters used to distinguish the genera, subtribes and tribes.

Taxonomy

Kelita A.R.Bean gen. nov.

a Ptiloto *floribus zygomorphis tepalis uncinatis et staminibus perfectis duobus tantum, ab* Omegandra *floribus zygomorphis tepalis quinque uncinatis et ab ambobus foliis denticulatis et fructibus parietibus crassis dignoscenda.*

Annual herbs; stems prostrate, longitudinally striate. *Leaves* alternate, exstipulate. *Inflorescences* axillary, spicate. *Flowers* solitary in bract, bibracteolate, all fertile, hermaphrodite, zygomorphic; tepals 5, all similar, densely lanate on outer surface. Fertile *stamens* 2, pseudostaminodes absent; anthers bilocular (4-locellate). *Ovary* superior, unilocular, uniovulate, placentation basal, ovule pendulous. *Style* simple, centrally attached; stigma not lobed, not capitate. *Fruits* indehiscent, hard, thick-walled.

Type: *Kelita uncinella* A.R.Bean

Abstract

A new genus in the family Amaranthaceae, *Kelita* A.R.Bean is described. The new genus belongs to Subtribe *Aervinae* Endl. and is related to *Ptilotus* R.Br. and *Omegandra* G.J. Leach & C.C. Towns. It differs from these genera by the denticulate leaf margins, the zygomorphic flowers, the uncinate awns on the tepals, and the thick-walled fruits. The genus comprises one species, *K. uncinella* A.R.Bean, which is described and illustrated. It is highly geographically restricted, and a conservation status of 'Endangered' is recommended.

Keywords: taxonomy, Australian flora, endangered species.

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Kelita uncinella A.R.Bean sp. nov.

Herba prostrata foliis alternis denticulatis, inflorescentiis spicatis axillaribus, floribus sessilibus zygomorphis staminibus duobus perfectis, tepalis uncinatis dense lanatis et capsula lenticulari parietibus crassis praedita.

Type: Queensland. SOUTH KENNEDY: 3 km (direct) NW of haul road overpass, near Newlands Coal Mine, WNW of Glenden, 8.vi.2009, *A.R. Bean 29009* (holotype: BRI (1 sheet + spirit); isotypes: CANB, E, K, L, MEL, NY, PRE, Z, to be distributed).

Prostrate *annual herb* with numerous stems radiating from a central rootstock; *stems* up to 1.2 m long, longitudinally striate, glabrescent, not rooting at the nodes. Juvenile plants with *leaves* opposite for 2 or 3 pairs, then alternate. Mature plants with *leaves* alternate, ovate to rhomboid, glabrous, petioles absent or up to 12 mm long; laminae 30–70 mm long, 13–30 mm wide, dark green above, paler below, midvein conspicuous, raised on underside, secondary veins penninerved, easily visible on underside; margins denticulate, with 20–100 teeth on each side, each 0.1–0.2 mm long; base attenuate, apex acute to mucronulate. *Inflorescences* spicate, sessile, axillary, solitary or branched, cylindrical, 7–27 mm long; rachis densely pubescent, with tangled uniseriate hairs. *Bracts* 1 per flower, narrowly-ovate, 1.5–2 × 0.7–0.8 mm, membranous, hyaline, glabrous, with a prominent midrib, apex acuminate, persistent on rachis; *bracteoles* 2 per flower, ovate, 2.4–2.8 × 1–1.5 mm, membranous, hyaline, glabrous, keeled, with a prominent midrib, apex acuminate, persistent on rachis. Pedicels absent. *Flowers* zygomorphic, dorsiventrally flattened, long axis perpendicular to rachis, bracteoles at either end of long axis. Tepals 5, free to base, apparently never opening widely, all similar in size, shape and indumentum, comprising tepal body and narrow terminal awn; tepal body narrowly oblong to narrowly elliptic, 2.3–2.8 mm long, 0.4–0.5 mm wide, herbaceous with scarious margins; dorsal surface with very dense tangled, woolly, simple, pale brown hairs, obscuring an otherwise conspicuous midrib; ventral surface stramineous, without veins, glabrous; terminal awn 0.3–0.8 mm long, slender, glabrous, apex uncinate. *Staminal cup* membranous, hyaline, c. 0.4 mm high; perfect stamens 2, staminodes 3 with anthers completely lacking; filaments slender, 0.6–0.8 mm long; anthers white, 0.2–0.3 mm long. *Ovary* sessile, broadly lenticular, 0.8–1 mm long at anthesis, glabrous; style straight, tapering, 0.4–0.6 mm long, glabrous; stigma not expanded, not lobed. *Fruits* lenticular, c. 1.5 mm diameter excluding style, stramineous to brown, 1-seeded, thick-walled, indehiscent, style persistent. Seed lenticular, completely filling fruit cavity, c. 1.1 mm diameter, with a thin brown crustaceous integument. Figs. 1–2.

Specimens examined: **QUEENSLAND.** SOUTH KENNEDY: 2 km W of Newlands Access road, Newlands Mine, NW of Glenden, 2.iv.2009, *R. Hendry & K. Wormington RH068* (BRI); 3 km (direct) NW of haul road overpass, near Newlands Coal Mine, WNW of Glenden, 8.vi.2009, *A.R. Bean 29013* (BRI, NSW); 600 metres N of Glenden-Collinsville road, 3.6 km from Newlands turnoff, 9.vi.2009, *A.R. Bean 29051* (BRI); ditto, *A.R. Bean 29052* (BRI, CNS, DNA).

Distribution and habitat: *Kelita uncinella* is known only from the vicinity of the Newlands coal mine about 130 km west of Mackay in Queensland. It grows on the slopes of tertiary plateaux (or 'jump-ups'), appearing to prefer south-facing slopes. The vegetation is a woodland of *Acacia shirleyi* Maiden, with 'scrub' elements in the understorey, e.g. *Erythroxylum australe* F.Muell., *Croton insularis* Baill., *Acalypha eremorum* Müll. Arg. and *Grevillea helmsiae* F.M.Bailey. The grassy ground layer is rather sparse, with *Ancistrachne uncinulata* (R.Br.) S.T.Blake, *Paspalidium* sp. or *Leptochloa decipiens* (R.Br.) Stapf ex Maiden. The shallow soil is a pink, gravelly loam.

Phenology: Flowers and fruits are recorded from April to June, but the phenology remains poorly known.

Affinities: *Kelita* is closely related to *Ptilotus* and *Omegandra*, and the differences are summarised in Table 1. The leaf margins of *Kelita* are inconspicuously (but consistently) denticulate, a feature relatively uncommon in the family, and not found in either *Ptilotus* or *Omegandra*. Very few species of *Ptilotus* have their inflorescences sessile in the axils of fully developed leaves; those that do (e.g. *P. murrayi* F.Muell.) have other characteristics that are typical of *Ptilotus*.

The flowers of *Kelita* are zygomorphic, more specifically dorsoventrally flattened, with a bracteole at each end of the long axis. This flattening can be observed in young flowers near the apex of the inflorescences, as soon as the developing perianth emerges from between the bracteoles, and persists to the fruiting stage. At no time do the tepals appear to open widely as they do in *Ptilotus* and *Omegandra*.

Figure 1: *Kelita uncinella*: A. flowering branchlet × 0.8; B. flowering spikes × 6; C. flower × 12; D. Stamens and staminal cup × 24; E. ovary, style, stamens and staminal cup × 24; F. perfect stamen × 24; G. Seed × 24; H. Bract and bracteoles × 12. All from *Bean 29009*.

In both of those genera, flowers are actinomorphic. The tepals are consistently five in *Kelita*, providing a strong contrast to the 4-tepaled flowers of *Omegandra*. The tepals of *Kelita* have a stout conspicuous midrib (although normally obscured by indumentum), while the midrib in the other genera is relatively obscure. In *Kelita*, all of their tepals have a terminal awn with an uncinate apex; uncinate tepal apices are unknown in *Ptilotus* or *Omegandra*, although this feature is found elsewhere in the family, e.g. the outer tepals of *Cyathula* spp.

The number of perfect stamens in *Kelita* is always two, as in *Omegandra*. The stamen number for the large genus *Ptilotus* varies between species, but the most

Figure 2: A. Mature healthy plant of *Kelita uncinella* in natural habitat.
B. Flowering branchlet of *Kelita uncinella* in natural habitat.

common number is five. Pseudostaminodes are absent in *Kelita*, while they are frequently present in *Ptilotus*. The stigma of *Kelita* is unexpanded and unlobed, while that of *Omegandra* is shortly bilobed and *Ptilotus* stigmas are capitate (expanded in comparison with the style). The fruits of *Kelita* are completely indehiscent, with a thick hard pericarp surrounding the seed, whereas the fruits of *Ptilotus* and *Omegandra* have a very thin membranous pericarp, which ruptures very easily.

Notes: The small hooks on the tepals of *Kelita uncinella* have presumably evolved as an aid to seed dispersal. The tepals and the capsule remain firmly attached to each other in the aging flower. Together they form the propagule, which readily detaches from the bract and bracteoles. I have observed that the propagules will attach themselves weakly to clothing, and hence presumably to animal fur, and could be transported for some metres before being dislodged. However, the hooks of *K. uncinella* are far less efficient for dispersal than those of some other local species, e.g. *Ancistrachne uncinulata* (Hooky grass).

Conservation status: *Kelita uncinella* is currently known from two sites about six kilometres apart. Fifty to one hundred plants were located at the site where the type specimen was collected, while at the other site, approximately 200 plants were present. Both sites are within 50 metres of cleared paddocks, but the steepness and infertility of the *Kelita* sites have prevented clearing there. Two weed species are presently associated with *K. uncinella* at the known sites, namely *Pennisetum ciliare* (L.) Link (Buffel Grass) and *Salsola tragus* L. (Roly Poly), but neither is common. The main threats are continued weed incursion and mining development.

Kelita uncinella is an annual plant and hence is present only after suitable rainfall and/or seasonal conditions.

Table 1. Comparison of *Ptilotus*, *Omegandra* and *Kelita*.

	Ptilotus	***Kelita***	***Omegandra***
Leaf margins	entire	denticulate	entire
Inflorescence position	mostly terminal, pedunculate; in a few species sessile, axillary.	sessile, axillary	sessile, axillary
Flower symmetry	actinomorphic	zygomorphic	actinomorphic
Tepal number	5	5	4
Tepal midrib	obscure	prominent	obscure
Tepal apices	acute, erose or obtuse	uncinate	acute
Number of perfect stamens	mostly 5, sometimes 4 or 3, rarely 2	consistently 2	consistently 2
Pseudostaminodes	often present	absent	absent
Stigma	not lobed, usually capitate	not lobed, unexpanded	bilobed
Fruit wall (pericarp)	thin, membranous, easily ruptured	thick, hard, persistent	thin, membranous, easily ruptured

Such plants are under-represented in herbaria, and are usually more common and widespread than herbarium records indicate. For this species however, the total lack of previous collections would suggest that it is either very geographically restricted, or that it needs extraordinary climatic conditions to trigger the germination and establishment of plants.

In accordance with the Red List criteria (IUCN 2001), a conservation status of 'Endangered' is recommended (EN C1 2a(i)).

Etymology: The generic name *Kelita* is a biblical name meaning dwarf, small or crippled, and is given in reference to the stature of the plant. The specific epithet is derived from the Latin *uncinatus* meaning 'with hooks', and the diminutive suffix *–ella*. This is in reference to the small hooks on the tepal apices.

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Phenetic analyses of *Ozothamnus hookeri* (Asteraceae), with the recognition of a new species, *O. cupressoides*

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Abstract

Phenetic analyses of the south-eastern Australian shrub *Ozothamnus hookeri* Sond. *s.l.* using 12 morphological characters scored from 72 herbarium specimens produced ordinations and classifications that revealed two discrete clusters. These clusters represent distinct populations from mainland Australia and Tasmania supporting the recognition of a separate species for the mainland taxon, here described as *O. cupressoides* Puttock & D. Ohlsen.

Keywords: kerosene bush, taxonomy, alpine shrub

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Introduction

Kerosene bush, *Ozothamnus hookeri* Sond. (Asteraceae) is a small alpine shrub that is widespread above the snowline throughout the alps of mainland Australia and the mountains of Tasmania (Burbidge 1958). It is most common on the margins of wet heathland communities (Puttock 1999) and, at least in Tasmania, in disturbed localities such as in areas that have been burnt (Kirkpatrick 1997). It can be distinguished from other south-eastern Australian species of *Ozothamnus* in having few-flowered capitula, minute leaves which have revolute margins and are closely appressed to the terete, unridged stems, and in the mainly alpine or subalpine habitat (Curtis 1963; Everett 1992; Puttock 1999).

Ozothamnus hookeri has been subjected to several nomenclatural changes. It was first published as *Baccharis*(?) *lepidophylla* DC. (de Candolle 1836) based on a specimen collected by Alan Cunningham from Mt. Wellington, Tasmania in 1819. Its generic placement was based presumably on a superficial resemblance to the New World genus *Baccharis* L. (Tribe Astereae), which also contains alpine species with small, appressed leaves (Muller 2006).

Joseph Hooker (1847) recognised the incorrect placement of the species and proposed the new combination *Ozothamnus lepidophyllus* Hook.f. In this publication he indicated that he was basing the new name on de Candolle's, thus making a new combination, although subsequent works (e.g. Bentham 1867; Burbidge 1958; APNI 2009) have attributed the name to Hooker alone. Nonetheless, this name is a junior homonym of *O. lepidophyllus* Steetz (1845) based on plants collected from King George Sound, Western Australia by James Drummond (holotype: W; isotypes include G, FI, MEL, MO, P, S). Apart from its disjunct occurrence in near-coastal Western Australia, the strongly reflexed leaves and capitula with distinct peduncles 1–3 mm long, clearly distinguish *O. lepidophyllus* Steetz from Hooker's species

of the same name. Sonder (1853) agreed with Hooker's generic placement and recognising the nomenclatural confusion, created the new name *O. hookeri* Sond. commemorating Joseph Hooker.

Mueller and Bentham took a conservative approach to the gnaphalioid composites and included several narrowly defined genera into a broadly circumscribed *Helichrysum* Miller. The characters that united members of the enlarged *Helichrysum* included opaquely scarious or petal-like involucral bracts, epaleate receptacles with few or no outer female florets, and the cypselas having a pappus of barbellate bristles. This resulted in the transferal of *Ozothamnus hookeri* to *Helichrysum* by Mueller (1865), but instead of retaining the epithet, Mueller deliberately proposed the new name *H. baccharoides* F.Muell. Bentham (1867) adopted Mueller's name in *Flora Australiensis*. Druce (1917) corrected Mueller's illegitimate name by making the new combination *Helichrysum hookeri* (Sond.) Druce. In attempting to resurrect the original epithet of de Candolle for the eastern alpine shrub, Tovey and Morris (1923) created a further homonym *Helichrysum lepidophyllum* (DC.) Tovey & P.F.Morris, as the Western Australian *O. lepidophyllus* had already been transferred by Mueller and published by Bentham (1867) as *H. lepidophyllum* F.Muell. ex Benth.

An infraspecific variety, *Helichrysum hookeri* var. *expansifolium* Sieber ex P.Morris & J.H.Willis (1942) was based on a Tasmanian plant with leaves that are spreading rather than being appressed to the stem. This taxon was later elevated to species rank by Burbidge (1958) and transferred to *Ozothamnus* by Anderberg (1991). The taxon is a putative natural hybrid between *O. hookeri* and *O. ledifolius* (A.Cunn. ex DC.) Hook.f. (Puttock in prep.; Kirkpatrick 1997).

Cladistics studies undertaken by Anderberg (1991) and Puttock (1994) on tribe Gnaphalieae using morphological, anatomical and cytological characters, and molecular studies by Bayer et al. (2002) and Galbany-Casals *et al.* (2004) have shown that including the Australian and New Zealand genera such as *Ozothamnus* with the African and Eurasian *Helichrysum* renders *Helichrysum* polyphyletic which necessitated the reinstatement of many segregate genera including *Ozothamnus*. Anderberg (1991) suspected *Ozothamnus* to be paraphyletic with respect to the other genera in the '*Cassinia* group' as defined by him, comprising *Apalochlamys*, *Cassinia*, *Haeckeria*, *Ixodia*, *Odixia* and *Ozothamnus*. *Cassinia* is nested within *Ozothamnus* in morphological and molecular analyses (Puttock, unpublished data), although Orchard (2004) suggested that a 'core', and by implication, monophyletic *Ozothamnus* could be identified. Further study in this group may show that it is necessary to propose further combinations to maintain monophyly within the *Cassinia* group.

The differences between mainland Australian and Tasmanian specimens of *Ozothamnus hookeri* were noted by Puttock (1999, in prep.), where he suggests that mainland specimens had larger leaves and synflorescences with more numerous, pedunculate capitula. He considered these character states as being of sufficient difference to treat them as separate species. No morphological distinction between mainland and Tasmanian plants was noted in earlier floras (e.g. Everett 1992). To test Puttock's assertion, the present study uses phenetic analyses to determine the level of divergence between mainland and Tasmanian populations using a range of morphological characters. This study also investigates whether other possible forms occur within these areas.

Materials and methods

Plant material used in this phenetic study included 72 herbarium collections of *Ozothamnus hookeri s.l.* comprising 41 specimens from mainland Australia housed at MEL and 31 specimens from Tasmania received on loan from HO (Fig. 1). Several flowering specimens were selected for scoring from all geographically isolated areas of the species' range, which are used here to divide mainland Australia and Tasmania into smaller regions. This was done in order to encompass the full range of morphological variation that may exist within and between these areas. The specimens were examined under a dissecting microscope and scored for 12 morphological characters that were then used in multivariate analyses. These included four quantitative vegetative characters, seven quantitative floral characters and a binary floral character (Table 1). Lengths and widths were measured with the aid of a graticule lens. Five replicates were measured from each specimen for each quantitative character.

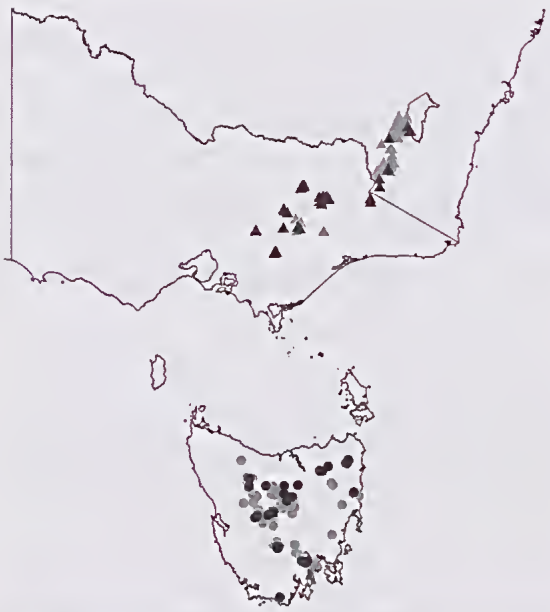

Figure 1: Distribution of *Ozothamnus cupressoides* (triangles) and *O. hookeri* (circles). Specimens used in analyses are indicated in black, other herbarium records in grey.

Analyses

For each character of each specimen the mean of the replicates was calculated and used in the analyses. Analyses were undertaken with the computer program PATN (Belbin 2004) based on a dissimilarity matrix using Gower's (1971) association coefficient also constructed in this program. The Gower metric is a range-standardised coefficient that can be applied to both the binary and quantitative characters used in this data set. Ordination and classification techniques were employed to identify clusters of similar individuals and to determine how distinct these clusters are from each other.

Ordination was undertaken by semi hybrid multidimensional scaling (SHMDS) which for these data favoured metric multidimensional scaling, to produce two- and three-dimensional ordinations. Multidimensional scaling is an iterative technique that assesses the locations of points in *n-space* relative to each other and attempts to represent the same spacing in a reduced number of dimensions so that visual interpretation can be made (Shepard 1962). The ordination with the lowest stress was selected after 100 iterations.

Sequential agglomerative hierarchal non-overlapping (SAHN) classifications were produced using the flexible clustering strategy of unweighted pair group method of averaging (UPGMA: Sokal & Michener 1958).

Ordinations and classifications were applied to the entire data set as well as separately to specimens of any discrete clusters that arose. This was done to see if the clusters that result from using the entire specimen set are an artifact of using a larger spread in character values.

Table 1. Characters used in analyses. All quantitative characters are measured to the nearest 0.1 mm. Character abbreviations are given in italics.

Quantitative characters
1. Leaf length measured from the apex of the leaf to the base of the revolute margin (*LL*)
2. Leaf width measured at the widest point (*LW*)
3. Width of the stem and leaves measured from the narrowest point immediately below the capitula (*WSL*)
4. Number of leaves visible from one side of the stem within 10 mm below the capitula (*NL*)
5. Number of capitula per synflorescence (*NC*)
6. Capitulum length measured from the apex of the inner involucral bracts to the pedicel tissue or base of the capitulum (*CL*)
7. Number of involucral bracts per capitulum including all series (*NB*)
8. Length of the inner involucral bracts (*BL*)
9. Number of florets per capitulum (*NF*)
10. Length of floret measured from the apex of the perianth lobes to the point of attachment with the receptacle (*FL*)
11. Pappus length measured from the point of attachment on the ovary to the apex of the pappus (*PL*).
Qualitative characters
1. Capitula sessile (0), pedunculate (1)

Photographs were taken using an Olympus DP71 camera set up on an Olympus SZX16 microscope of a specimen representative of each of the clusters that were obtained from the analyses.

For each of the quantitative characters, box plots were constructed from the mean of the character replicates for each specimen belonging to a cluster as well as for specimens belonging to each smaller region. This therefore constructs a box plot for each cluster or region for each quantitative character so that differences in mean character values can be observed between clusters or regions, demonstrating the characters responsible for contributing to any difference that occur between clusters and between regions.

Results

The two-dimensional ordination obtained using SHMDS (stress=0.1466, 100 iterations) shows that all specimens from the mainland form a cluster and all specimens from Tasmania form another cluster separated from one another in ordination space (Fig. 2). Also shown in the ordination (Fig. 2) is the location of specimens according to the region that they inhabit within the mainland or Tasmania. All regions are positioned in ordination space so that their specimens are interspersed among the specimens of other regions and as a result no region forms a cluster that shows no overlap with specimens from other regions. For some regions such as the Baw Baw Plateau the specimens are congregated into a cluster but the ordination space the specimens occupy is also shared by specimens from other regions, in this case from Lake Mountain. The three-dimensional ordination (stress=0.0882, 100 iterations) gave similar results, so are not presented.

Congruence is gained from the UPGMA phenogram (Fig. 3) that produces two clusters (dissimilarity=0.8879) that correspond to the specimens of the mainland and those from Tasmania. Other than these clusters there are no other groups that cluster on a geographic basis.

Ordinations in both two- and three-dimensions and UPGMA phenograms generated for specimens from the mainland or Tasmania separately also failed to distinguish any other discrete groups.

Box plots of the mean values of characters of each specimen from either the mainland or from Tasmania (Fig. 4), indicate that the largest difference between the mainland and Tasmanian specimens is the character leaf length (*LL*). There is no overlap in the range of mean values of this character for these specimens. Substantial distinctions in mean character

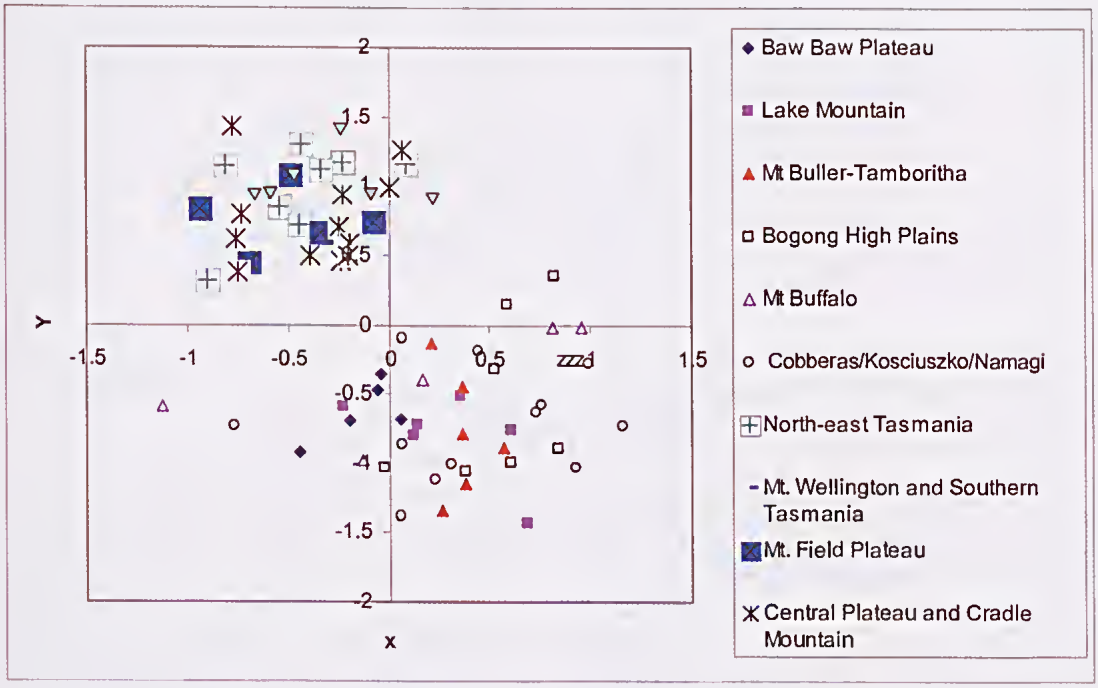

Figure 2: Two-dimensional ordination obtained using SHMDS (stress=0.1466, 100 iterations)

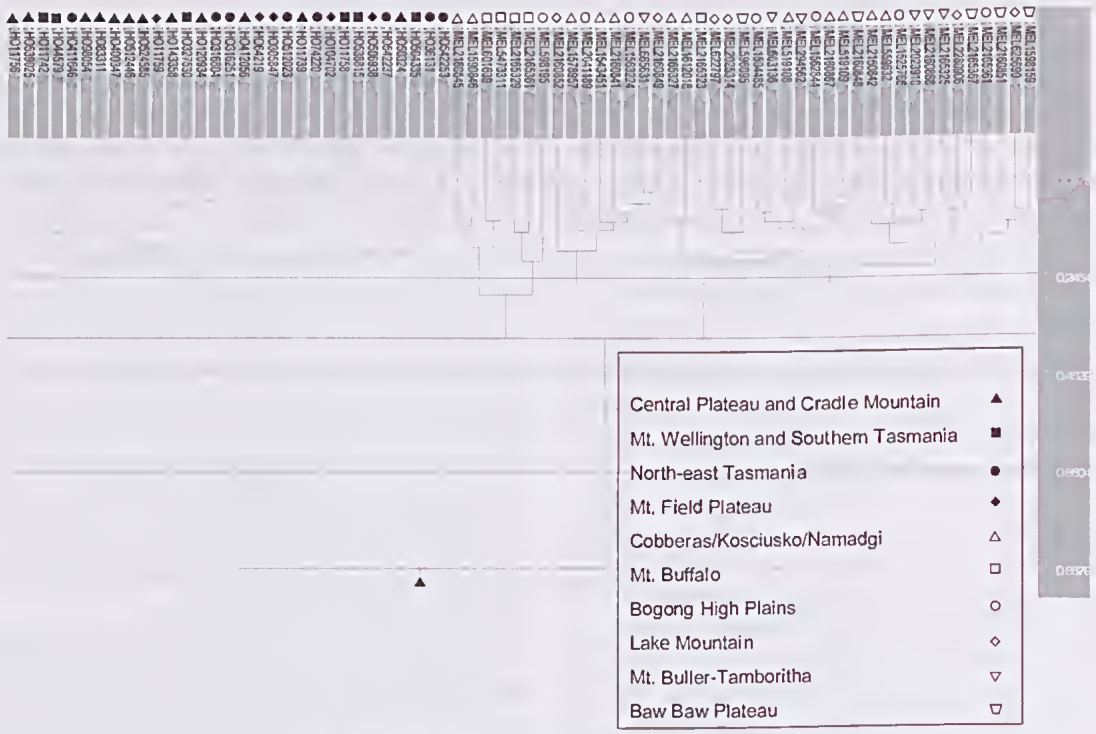

Figure 3: Phenogram from the UPGMA analysis

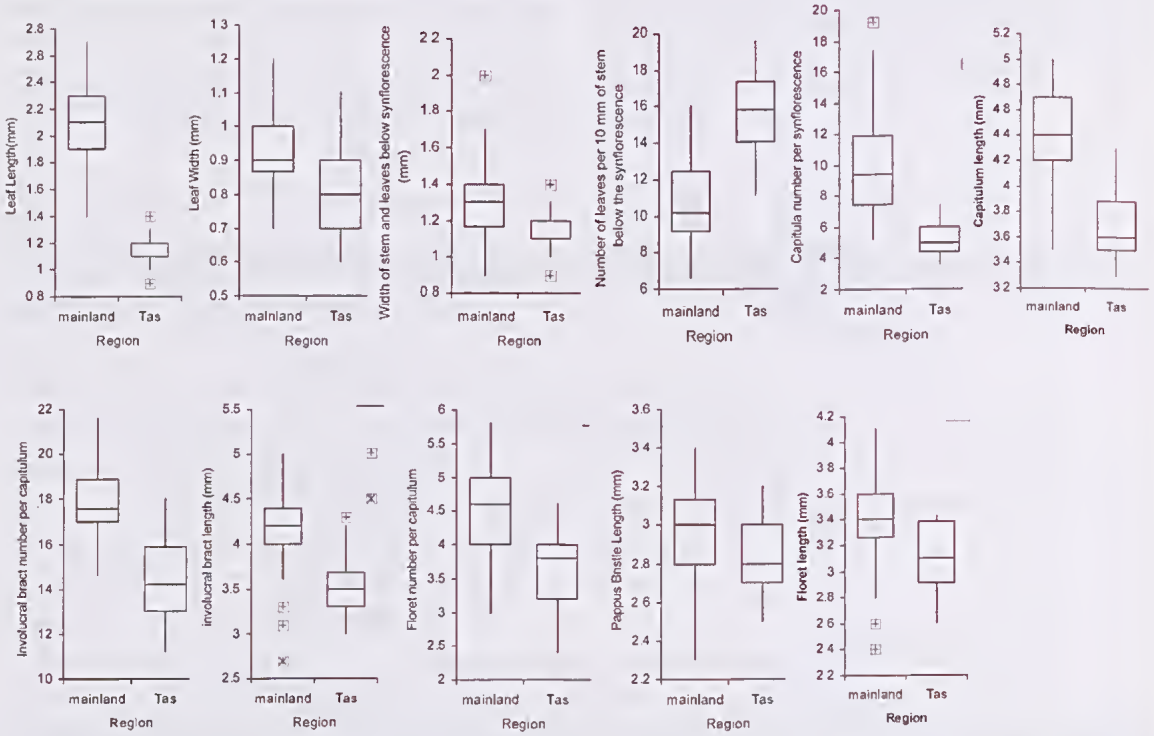

Figure 4: Box plots of mean values for each quantitative character compared between the mainland and Tasmania

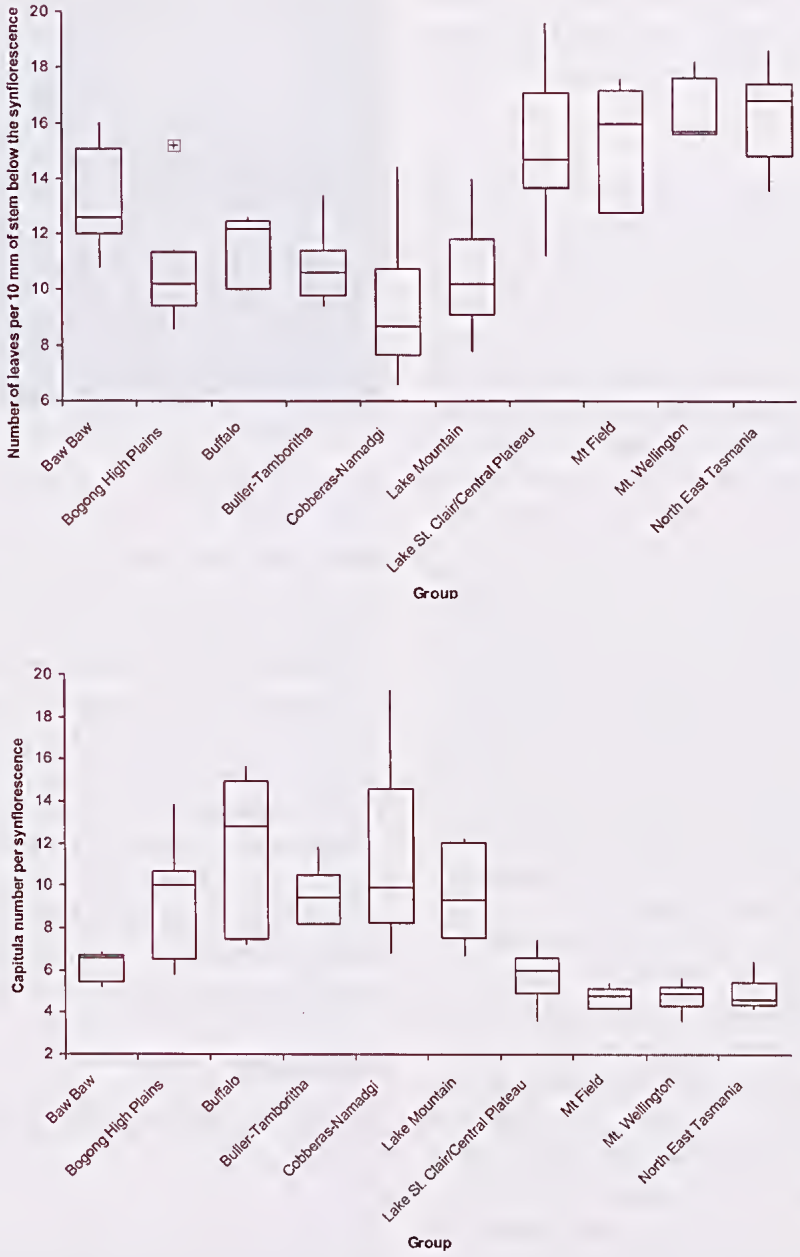

Figure 5: Box plots of mean values for leaf numbers per cm (left) and capitula per synflorescence (right) compared between regions of the mainland and Tasmania

values can also be seen between the mainland and Tasmanian specimens for characters measuring leaf density (*NL*), number of capitula per inflorescence (*NC*), capitulum length (*CL*), number of involucral bracts per capitulum (*NB*) and length of the inner involucral bract (*BL*). There are no overlaps in the interquartile ranges (IQRs) for these characters. For all other characters the differences are only minor. For all characters except for *NL*, values were larger for specimens from the mainland than those from Tasmania. Box plots for selected characters for populations from particular regions in the mainland and Tasmania indicate an approach of mainland plants from the Baw Baws to Tasmanian populations for the characters *NL* and *NC* (Fig. 5).

However, in all other characters the mean values of the characters in the Baw Baw Plateau specimens are more similar to specimens of the other mainland regions.

Discussion

All analyses recognise that the mainland and Tasmanian specimens belong to distinct groups. This is largely due to the character *LL*, which shows no overlap in the mean character values, and the pedunculate capitula of all the mainland specimens contrasting with the consistently sessile capitula of the Tasmanian specimens (Fig. 6). These characters would therefore be useful for discriminating between mainland and Tasmanian specimens. The overlap in the IQR of the characters *NL* and *NC* is caused by the specimens from the Baw Baw Plateau. A more pronounced difference is seen between these characters for all other regions of the mainland and Tasmania as was noted by Puttock (1999) for the character *NC*. Despite the specimens from the Baw Baw Plateau approaching those from Tasmania in terms of the characters *NL* and *NC* (Fig. 5), in all other characters analysed, their values are more typical of other mainland specimens. In common with all other mainland specimens they share the diagnostic characters (*LL* and pedunculate capitula) separating the mainland and Tasmanian groups.

None of the analyses employed support the recognition of groups within the mainland or Tasmanian entities. Despite some groups such as Baw Baw Plateau being clustered closely together, the variation they possess in the characters measured is also possessed by other regions as indicated by considerable overlap in the ordinations and clustering among other groups in the UPGMA. This demonstrates that they are not a discrete group and they could not be acknowledged as a separate taxonomic entity. The lack of distinctiveness between Tasmanian groups is perhaps surprising given the recognition of major differences in the vegetation composition between the western mountains and the eastern mountains in Tasmania according to classification systems of Australian alpine vegetation (Kirkpatrick 1986, 1997).

Due to the several characters that consistently differ between the mainland and Tasmanian specimens, reflected by the large distance separating clusters in ordination space and the high dissimilarity between such clusters in the UPGMA, it is here proposed that all mainland plants formerly included within *Ozothamnus hookeri* be recognised as a separate species, *O. cupressoides* Puttock & D.Ohlsen. This name has already been applied to many specimens in Australian herbaria and databased with that name in Australia's Virtual Herbarium (AVH 2009; Puttock *in sched.*).

Figure 6: Branchlet and synflorescences of mainland *Ozothamnus cupressoides* (left) and Tasmanian *O. hookeri* (right). Scalebar = 2 mm.

The following description of *Ozothamnus cupressoides* and recircumscription of *O. hookeri* are based on measurements used in the phenetic analyses as described above, augmented with measurements from all specimens in Australian herbaria (Puttock, unpubl. data). Outlying measurements are bracketed.

Taxonomy

Ozothamnus cupressoides Puttock & D.Ohlsen sp. nov.

O. cupressoides Puttock *in sched.*.

Helichrysum hookeri non (Sond.) Druce; Burbidge (1958); 281, Fig. 11; N.T. Burbidge and M. Gray, *Flora of the A.C.T.* 385 (1970); J.H. Willis, *Handbook to plants in Victoria* 2: 718 (1973).

Ozothamnus hookeri non Sond.; Everett (1992).

Ozothamnus sp.1. C.F. Puttock in N.G. Walsh and T.J. Entwisle (eds) *Flora of Victoria* 4: 739, Fig. 144e (1999); M.G. Corrick and B.A. Fuhrer, *Wildflowers of Victoria* 35 (2000); *Ozothamnus* sp. (*aff. hookeri*) Sond. A. Costin, M. Gray, C. Totterdell and D. Wimbush, *Kosciuszko alpine flora*, pp. 205, 344 (2000).

Ab Ozothamno hookeri *Sond. foliis longioribus ((1.2–)1.5–3.5(–3.8) mm) ramulis sparsioribus, pedunculis capitularum distinctis (sed minus quam 1.2(–2) mm longis) et inflorescentis capitulis pluribus (3–)5–15(–35) compositis differt.*

Type: Victoria. Alpine National Park, Bogong High Plains. Beside Big River Fire Trail, c. 300 m from High Plains Rd, 28.i.2009, *J.A. Jeanes 2125 G. Lay, K. Lake & P. Evans* (holotype: MEL2325620; isotypes CANB, K, NSW, S).

Illustrations: N.T. Burbidge *Aust. J. Bot.* 6: 281 Fig. 11 (1958); N.G. Walsh and T.J. Entwisle *Fl. Victoria* 4: Fig. 144e (1999); A. Costin, M. Gray, C. Totterdell and D. Wimbush, *Kosciuszko alpine flora*, p. 205 (2000).

Erect *shrub* 0.6–1.2 m tall, to 0.8 m diam.; main lateral branches many; upper branches with an indumentum of very dense, loose mat of white cottony hairs; glandular hairs absent; synflorescence shoots many; 40–120 mm long. *Leaves* erect and appressed to stem, sessile, not amplexicaul nor decurrent; lamina ovate to narrowly triangular, (1.2–)1.5–3.5(–3.8) mm long, 0.5–0.9(–1.7) mm wide, strongly revolute, curled to the midvein; base auriculate; apex rounded, not mucronate; adaxial surface viscid, glabrescent; cottony hairs absent; glandular hairs sparse. *Synflorescences* dense umbellate heads 5.5–9.0 mm long, 9.5–13 mm diam., with (3–)5–15(–35) pedunculate capitula. Capitula in bud dull yellow; at anthesis cylindrical, 3.7–5.0 mm long, 1.2–1.3 mm wide, viscid borne on peduncles up to 1.0 mm long. *Receptacular* axis 0.5–0.7 mm long, 0.3–0.4 mm wide; apex small, flat to slightly elongate. *Involucral bracts* 15–22, 5–7 inner involucral bracts subtending florets or several and 1–3 paleae without florets; outermost bracts straw yellow, ovate, 10–12, 2.4–2.8(–3.8) mm long, 0.7–0.9 mm wide, glossy; cottony hairs absent; stereome 2.1–2.4 mm long; *innermost bracts* spathulate, 5–6, 3.6–4.5(–5.4) mm long, 0.5–0.8 mm wide; stereome 2.2–3.1 mm long; lamina deltoid, 0.8–1.0(–1.4) mm long, 0.8–0.9(–1.1) mm wide, sub-erect, plicate, white and occasionally with purple immediately adjacent to the stereome; margin lacerate; paleae (when present) slightly narrower than the other innermost bracts. *Female florets* 0; hermaphrodite florets 3–6, 3.5–4.5 mm long; ovary cylindrical 0.7–1.0 mm long. *Pappus* of 26–34 flattened bristles 2.8–3.7 mm long, barbed throughout; apex narrow clavate. *Corolla* white, very narrow crateriform, 2.8–3.6 mm long. *Cypsela* narrow ovoid, 1.2–1.3 mm long, 0.4–0.5 mm diam., brown; duplex hairs dense; glandular hairs absent; pappus persistent.

Specimens used for phenetic analyses: **NEW SOUTH WALES.** 8ig 8oggy Creek, 2 km. 5. of Dead Horse Gap, c. 10 km. 5SE of Mt Kosciusko summit, alt: 1600 m, 18.iv.1972, *B.G. Briggs 3319* (MEL216084, NSW);Three Mile Dam, Kiandra-Cabramurra road, alt: 1470 m, 11.iv.1986, *A.N. Rodd 5382, S. Corbett & D. Wilson* (MEL, NSW); **AUSTRALIAN CAPITAL TERRITORY.** Namadgi National Park, 5cabby Range, 3.5 km SSW of Mt Kelly. alt: 1560 m, 11.iii.1992, *I.R. Telford 11553* (AD, 8ISH, HO, K, MEL1012018, NSW, PERTH, US); Murrays Gap Flats, Bimberi Range, alt: ca. 5000 ft, 15.i.1961 *P. Darbyshire 160* (CAN8, MEL2160845).**VICTORIA.** Baw Baw Plateau Mt St Gwinnear, c. 300 m south-west from summit, alt: 1460 m, 26.ii.1991, *N.G. Walsh 3063* (MEL1548159); Echo Flat, Lake Mountain, 15.ii.2006, *J.A. Jeanes 1575* (MEL2280906, K); 5ummit of the Bluff, 27.i.1963 *T.B. Muir 2757* (MEL2160868); Near summit of Mt Reynard, 28.i.1984, *S.J. Forbes 1950*, (MEL665631, MEL665632); Lost Plain, N side of Tamboritha Rd, 7.iii.1993, *P.C. Jobson 1994* (MEL2023910); Mt 8ulla [Buller], *s.d., J.L. Soues s.n.* (MEL2165326); 2.7 km SE of General Store at Hotham Heights, 23.ii.1984, *D.E. Albrecht 226 & B.J. Conn* (MEL1525766); Mt Feathertop, 16.ii.1985, *F. Cootes 16* (MEL1562844); 8ogong High Plains, 0.7 km NE Mt Cope, 20.i.1981, *H. von Rees 262* (MEL598195); Mt Buffalo, 21.ii.1963, *J.H. Willis s.n.* (MEL2165361); Black Mountain Road, 7.2 km. ca south of Mt Cobberas No. 1, 17.i.1984, *D.M. Porkes* (MEL1543451).

Etymology: From the Greek meaning 'cypress-like', from the similarity of the branchlets with their appressed, scale-like leaves to members of the genus *Cupressus* L.

Distribution and conservation status: Widespread throughout alpine and higher subalpine regions of mainland Australia south from Ginini Swamp, including Kosciusko National Park in New South Wales, Namagi National Park in Australian Capital Territory and Mt Cobberas, the Bogong High Plains, Mt Buffalo, Mt Buller, the Baw Baw Plateau and Lake Mountain in Victoria. It has been recorded at altitudes between 1300 and 1850 metres above sea level. The conservation status of *Ozothamnus cupressoides* is assessed as 'of least concern' according to IUCN criteria (IUCN 2001), although increasing global temperatures could lead to an assessment of higher concern.

Habitat: Most frequent at open localities in

grassland and heath and common near bogs and drainage lines. Occasionally in the margins of open *Eucalyptus pauciflora* Sieber ex Spreng. woodland. Soils are usually peats developed on sedimentary, metamorphic, granitic or occasionally basaltic parent material.

Phenology: Flowers December–February. Fruits March–April.

Vernacular names: Scaly Everlasting, Lattice Everlasting

Notes: The new species differs from *Ozothamnus hookeri* by its longer (1.2–3.8 mm) leaves that are less densely arranged on branchlets, the short pedunculate capitula, and by the more numerous capitula, (3–) 5–15(–35) per synflorescence. Puttock (1999, p. 739) described this species as *Ozothamnus*. sp.1 and mentioned them possessing 1–3 receptacular bracts (paleae). In this treatment the inner ring of bracts not subtending a floret are considered as paleae or receptacular bracts. There are usually six inner bracts, however, there are often fewer florets.

The capitula are borne on very short peduncles in this species. In most cases they are only visible with the aid of a hand lens or microscope. The peduncles are long enough to allow separation of capitula from synflorescences in herbarium specimens using fine forceps without causing any damage to the capitulum, c.f. *O. hookeri* where the capitula disintegrate when attempting to separate them from the synflorescence in herbarium material.

Ozothamnus hookeri Sond., *Linnaea* 25: 509 (1853); Hooker.f. *Fl. Tasman.* 201, pl. LV (1856); J.B. Kirkpatrick, *Alpine Tasmania* 23 (1997).

Helichrysum hookeri (Sond) Druce, *Rep. Bot. Soc. Exch. Club Brit. Isles* 1916: 626 (1917); W.T. Curtis, *Students flora of Tasmania* 2: 337 (1963).

Basionym: *Baccharis lepidophylla* DC., *Prodr.* 5: 427 (1836); *Ozothamnus lepidophyllus* (DC.) Hook.f., *London J. Bot.* 6: 120 (1847), *nom. illeg. non* Steetz in Lehmann, *Pl. Preiss.* 1: 468 (1845). *Helichrysum lepidophyllum* (DC.) Tovey & P.F.Morris, *Proc. Roy. Soc. Victoria* 35: 195 (1923) *nom. illeg., non H. lepidophyllum* (Steetz) F.Muell. ex Benth., *Fl. Austral.* 3: 633 (1867).

Type: Tasmania. Van-Diemen prope Hobart- Town ad summitatem frigidam montis Wellington alt. 4100 ped angl. Supra mare legit cl. A. Cunningham (holo: G-DC!, iso: K!).

Helichrysum baccharoides (DC.) F.Muell. ex Benth. *Fl. Austral.* 3: 633 (1867), *superfl. nom. nov.*

Illustration: J.D. Hooker *Fl. Tasman.* pl. 55 (1856).

Erect *shrub*, 0.5–1(–2) m tall; to 0.7 m diam.; main lateral branches many; upper branches with an indumentum of very dense, loose mat of white cottony hairs, glandular hairs absent; synflorescence shoots many, 40–60 mm long. *Leaves* erect and appressed to stem, sessile, not amplexicaul nor decurrent; lamina ovate, 0.5–1.5(–2.5) mm long, 0.5–1.0(–1.8) mm wide, strongly revolute, curled to the midvein; base cordate; apex rounded, not mucronate; adaxial surface viscid, cottony hairs absent; glandular hairs sparse; scabrous uni- or biseriate hairs absent; abaxial surface with very dense, loosely matted, cottony hairs on lamina and midvein; glandular hairs sparse. *Synflorescences* dense umbellate heads 4.5–5.5 mm long, 6–9 mm diam., with (3–)4–6(–10) sessile capitula. Capitula in bud dull yellow, at anthesis cylindrical, 3.0–4.5 mm long, 1.2–1.3 mm wide, viscid. *Receptacular axis* 0.5–0.6 mm long, 0.3–0.4 mm wide; apex small, flat to slightly elongate. *Involucral bracts* 14–19, 5–6 inner involucral bracts subtending florets or several and 1–2 paleae without florets; outermost bracts cream, ovate 6–9, 2.2–2.9 mm long, 0.8–1.0 mm wide, glossy; cottony hairs sparse, loosely matted; stereome 1.8–2.2 mm long; *innermost bracts* spathulate, 7–10, 3.7–4.4 mm long, 0.6–0.8 mm wide; stereome 2.2–2.8 mm long; lamina deltoid, 0.9–1.3 mm long, 0.7–1.0 mm wide, sub-erect, plicate, white and occasionally with purple immediately adjacent to the stereome; margin irregular; paleae (when present) slightly narrower than the innermost bracts. *Female florets* 0; hermaphrodite florets (2–)3–6(–7), 3.0–3.9(–4.4) mm long; ovary cylindrical, 0.5–0.9 mm long. *Pappus* of 26–36 flattened bristles, 2.8–3.4 mm long, barbed throughout; apex narrow clavate. *Corolla* white, very narrow crateriform, 2.7–3.5 mm long. *Cypsela* narrow ovoid, 1.2–1.3 mm long, 0.4–0.5 mm diam., brown; duplex hairs moderately dense; globular hairs absent; pappus persistent.

Specimens used for phenetic analyses: **TASMANIA**. Mt Barrow, on switchback just before plateau surface. 27.ii.2006,

M.F. Duretto 2113, A.M. Buchanan, A.M. Gray (HO); Mt Maurice-summit, *A.M. Buchanan 225* (HO); Little Plain, Blue River, Blue Tier, 1.ii.1878, *A. Simpson 1048* (HO, MEL); Little Mt Michael, 12.iii.1985, *M.J. Brown 873* (HO); Northern M road, Black Marsh c. 33 km N of Old Coach Road, 14.i.1995, *A.M. Gray 773* (HO); Headwaters of Mountain River, Mt Wellington, 13.i.1981, *A. Brown 104* (HO, MEL598317); Eastern shore of Ooze Lake, ii.1981, *A. Brown 211* (HO, MEL2103591); Mt Field National Park, 1 km E of Lake Dobson, 14.ii.1989, *J.R. Croft 10029 & M.M. Richardson* (CANB, CHR, HO, MEL713670, NSW); Great Lake, 31.iii.1891, *A. Simson 2337* (HO); Small creek on south side of Breona, Great Lake, 19.i.1990, *A.E. Orchard 6104* (HO); Quamby Bluff, summit, 7.iii.1986, *A. Moscal 12608* (HO); King William Saddle, 4.ii.1984, *A. Moscal 6133* (HO); Near Lake Rodway, Cradle Mountain, 30.i.1982, *A.M. Buchanan B65* (HO).

Distribution and conservation status: Occurs on the mountains of Tasmania generally, but largely absent from the south-west. Usually in the alpine and subalpine zone but occasionally at lower altitudes such as the Blue Tiers in the north-east. It has been recorded at altitudes between 500 and 1300 metres. The conservation status of *Ozothamnus hookeri* is assessed as 'of least concern' according to IUCN criteria (IUCN 2001).

Habitat: Most frequent at open localities in grasslands and heath and common near bogs and drainage lines. Occasionally in *Eucalyptus gunnii* Hook.f. woodland on the Central Plateau. At lower elevations occasionally it is found in mixed *E. delegatensis* R.T.Baker and *E. dalrympleana* Maiden woodland. Soils usually peaty or humic with variable degrees of drainage. Geology is variable including granite, dolerite and quartzite.

Phenology: Flowers January–February. Fruits March–April.

Vernacular name: Kerosene Bush.

Putative hybrids

Some 15 or more putative natural hybrids are known between species of *Ozothamnus*, and between *Ozothamnus* and *Cassinia* (Puttock unpublished data), the majority of which are sterile F1s.

Ozothamnus hookeri X *O. ledifolius* (A.Cunn. ex DC.) Hook.f. = *O.* X *expansifolius* (Sieber ex P.Morris & J.H.Willis)

Helichrysum hookeri var. *expansifolium* Sieber ex P.Morris & J.H.Willis, *Vict. Naturalist* 59: 87 (1942); *H. expansifolium* (Sieber ex P.Morris & J.H.Willis) N.T. Burb., *Austral. J. Bot.* 6: 278 (1958); *Ozothamnus expansifolius* (Sieber ex P.Morris & J.H.Willis) A.Anderb. *Opera Bot.* 104: 89 (1991).

Type: Tasmania. Cradle Mt, Feb. 1919, Sutton 2661 (holo: MEL307437).

Notes: Sterile F1 hybrid. In raising this taxon to species Burbidge (1958) was ambivalent on whether this represented a hybrid or not.

Ozothamnus cupressoides X *O. alpinus* (N.A.Wakef.) A.Anderb.

Representative specimen: Victoria, Langfords Gap near Falls Creek, *.D. Ohlsen 1B* (MEL2323803).

Notes: Putative hybrids between these two species have been reported on the Bogong High Plains near Falls Creek. These plants differ from typical *O. cupressoides* in the longer (3–3.5 mm) and broader (1.5–2.5 mm) leaves that are triangular to elliptic and not closely appressed to the stem, with the apex often recurved exposing most of the abaxial surface. The synflorescences are hemispherical and the florets are longer ((4–)4.5–5 mm) than those of *O. cupressoides*. Both putative parent species have been observed in the vicinity of these plants, flowering at the same time (D. Ohlsen pers. observ.).

Two mainland specimens mentioned by Morris and Willis (1942, p87) "Bogong and Mt. Wellington, Victoria .... bear a strong resemblance to *H. Hookeri*, var. *expansifolium*" and being "intermediate between *Backhousii* and *Hookeri*?" were at the time the undescribed species *Ozothamnus alpinus*.

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the late Esma Salkin, a founding member of the Australian Daisy Study Group, whose generosity and encouragement are gratefully acknowledged. CFP thanks the Australian Biological Resources Study for funding the revision of these species as part of the revision of *Ozothomnus* for the Asteraceae volume of the *Floro of Australio*. He also thanks the directors of AD, BRI, CANB, CBG, FI, K, MEL, MO, NSW, PERTH, US and W for the loan or use of facilities for the study of their holdings.

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Appendix 1

O. cupressoides

Further representotive specimens (total 104): **NEW SOUTH WALES**. Cascade Trail, 6 miles S. of Dead Horse Gap, 12.iii.1970, *J. Pickard and R. Coveny 2775* (MEL2160842, NSW); Kosciusko area, between Perisher Valley and Sawpit Creek, 19.ii.1990, *M.G. Corrick 10670* (MEL15789S7); Hillside above Daners creek (NW side) near junction with Pipers creek, Kosciusko N. P. 36°22'S 148°28'E, alt: 1600 m, 3.ii.1979, *L. Haegi 1611* (MEL, NSW). **VICTORIA**. Mt Mueller, 189S, *C.H. French, s.n.* (MEL2165367); Mt Mueller near Mt Baw Baw, 1889, *J. Melvin s.n.* (MEL2160848); Mt St. Phillack on highest point, 20.iii.19S1, *J.H. Willis, s.n.* (MEL21608S1); Mustering Flat, Mount Baw Baw Plateau, 19.ii.1980, *N.G. Wolsh 477* (MEL59609S); Echo Flat, Lake Mountain,

21.iii.1995, *P.C. Jobson 3481* (CANB, MEL2025314); Frost Hollow, Lake Mountain, 11.i.1973, *B. Conn, s.n.* (MEL625690); Lake Mount[ain], ii.1926, *P.R.H. StJohn, s.n.* (MEL1622797); Lake Mountain Echo Flat, 17.ii.1963, *H.I. Aston, s.n.*, (MEL2160849); Central Highlands, Lake Mt., 6.ii.1943, *J.H.Willis, s.n.* (MEL2160852); Mt. Buller, Boggy Creek area, 30.i.1983, *C.W. Huggins 73* (MEL294562); Mt Buller, top of Old Hut 5pur, 27.i.1981, *N.G. Walsh* (AD, MEL663136); Bogong High Plains, Buckety Plain, 28.i.1966, *A.C. Beauglehole 15762* (MEL1504485); Mt Loch, 24.ii.1983, *C. Beardsell, s.n.* (MEL1563224); Langfords West Aqueduct, 14.6 km 5E of Falls Creek, 23.ii.1996, *P.C. Jobson 4132*, (CANB, MEL2041189, NSW); Bogong High Plains Between Niggerheads and Mt. Fainter-at waterfall, 26.i.1967, *A.C. Beauglehole 22521* (MEL15044489); Mount Buffalo, 24.i.1973 *M.A. Todd 104* (MEL547331); Summit of Buffalo Mountains, x.1891, *C. Walter, s.n*, (MEL2165366); Mt. Buffalo National Park, between snowplain and The Gap, 28.i.1982, *P.S. Short 1399* (MEL601839); Mt. Buffalo, Lake Catani, 29.i.1938 *J.H. Willis, s.n.* (MEL2165323); Cobberas No. 1., 28.i.1971, *A.C. Beauglehole 36604 & E.W. Finck* (MEL519108); Middle Peak area, Cobberas Mts., 25.i.1971, *A.C. Beauglehole 36512 & E.W. Finck* (MEL519109); Cobberas Mts, 10.ii.1946, *J.H. Willis, s.n.* (MEL2160867); Mount Cobberas *s.d., F. Mueller, s.n.* (MEL).

O. hookeri

Further representative specimens (total 125): **TASMANIA.** Mt Barrow plateau, 27.ii.2006, *M.F. Duretto 2099, A.M. Buchanan & A.M. Gray* (HO); Mt Barrow, track near summit, 1.iii.1996, *A.C. Rozefelds 187* (HO); Mt Barrow, 28.i.1980, *M.G. Noble 28994* (HO); Mt. Wellington, *s.d., C.F. Puttock 10* (CANB, HO); Mt. Wellington, 31.i.1840, *R.C. Gunn 123* (HO); Mt. Wellington, Collins Bonnet Track, 8.ii.1947, *J. Somerville s.n.* (HO); Dead Island, Mt Wellington, 6.ii.2000, *A.C. Rozefelds1623* (HO); Mt. Field National Park, c. 0.8 km 5E of Lake Dobson, 24.i.1983, *P.S. Short 1829* (HO, MEL626458, 2165509); Mt. Field, iii.1902, *L. Rodway 410* (HO); Kangaroo Moor, Lake Fenton, Mt Field National Park, 26.iii.1932, *O. Rodway 116* (HO); Wombat Moor, Mt. Field National Park, *G. Kantvilas s.n.*, (HO); Poatina Intake Road, 17.iii.2006, *M. Visoiu 174 & N. Kent* (K, KRA, HO); 5 ridge of Western Bluff, 13.iv.1986, *P. Collier 1332* (HO); Below Pine Tier Lagoon, 2.ii.2000, *B. French 451* (HO); Between Derwent Bridge and Bronte, 27.xi.1949, *N.T.* Burbidge *3403* (CANB, HO); Mt Rufus Canal Road, 8.i.1986, *S.J. Jarman s.n.* (HO); Iris River- Cradle Valley Rd, crossing, 10.5 km N. Waldheim, 20.i.1982, *S.J. Forbes 1242* (HO, MEL663048, PERTH); Cradle Mountain area, iii.1949, *J. Somerville s.n.* (HO).

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A revision of the *Leucochrysum albicans* (Asteraceae: Gnaphalieae) complex

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Abstract

A morphometric study of the *Leucochrysum albicans* (DC.) Paul G.Wilson complex (*L. albicans*, *L. graminifolium* (Paul G.Wilson) Paul G.Wilson and *L molle* (DC.) Paul G.Wilson,), concluded that five taxa be recognized from the current six. *L. albicans* subsp. *alpinum* (F.Muell.) Paul. G.Wilson is elevated to specific rank as *L. alpinum* (F.Muell.) R.J.Dennis & N.G.Walsh and *L. albicans* var. *buffaloensis* (Paul G.Wilson) Paul G.Wilson is reduced to synonymy under the typical variety. Other members of the complex are maintained at their current ranks.

Keywords: species complex, morphometric analysis, scanning electron microscopy

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Introduction

The *Leucochrysum albicans* complex comprises a group of closely related taxa that have caused taxonomic confusion in the past; e.g. "Variation between the taxa within *Helipterum albicans* [now *Leucochrysum* spp.] appears ... to be continuous ... each taxon intergrades with one or more of the other taxa" (Wilson, 1960, pp. 163, 164). The *L. albicans* complex is here regarded as consisting of *Leucochrysum albicans*, *L. molle*, and *L. graminifolium*. The two remaining members of the genus, *L. fitzgibbonii* (F.Muell.) Paul G.Wilson and *L. stipitatum* (F.Muell.) Paul G.Wilson, are morphologically distinct from the *L. albicans* complex and both have a Central Australian distribution (Wilson 1992). They were not included in this study.

Leucochrysum molle has a wide distribution including central and eastern South Australia, southern Queensland, western New South Wales, and northern Victoria (Fig. 10). *L. molle* has linear to broadly obovate, lightly cobwebbed leaves and triangular, ovate to suborbicular yellow involucral bracts. It is an annual whereas other members of the genus are perennials (Wilson 1960). Occurring in sandstone outcrops of the central tablelands in New South Wales, *L. graminifolium* has a woody stem, usually retaining remnants of previous years' growth. The linear to filiform leaves are light green, the dorsal surface glabrescent while the ventral side remains covered in a cobwebbed mat of hair and the margins are tightly revolute. The involucral bracts are narrow to ovate (Harden 1992). *Leucochrysum albicans* sens. lat. (sensu Wilson 1992) extends from south eastern Queensland, through eastern New South Wales, the Australian Capital Territory, much of Victoria and into Tasmania.

Leucochrysum albicans sensu Wilson (1992) has two subspecies; *albicans*, and *alpinum*, the latter occurring only in the alpine regions of Victoria and New South Wales. Wilson (1992) noted that *L. albicans* subsp. *alpinum* differs from subsp. *albicans* by having obovate to oblanceolate, densely lanuginose, flat leaves with slightly incurved margins. The inner involucral bracts are always white and the outer involucral bracts brown to purple, and elliptic to ovate.

Royal Botanic Gardens Melbourne

Leucochrysum albicans subsp. *albicans* has linear to oblanceolate, cottony leaves with recurved to tightly revolute margins. It currently includes three varieties: the typical variety, var. *buffaloensis* (Paul G.Wilson) Paul G.Wilson and var. *tricolor* (DC.) Paul G.Wilson. The typical variety is widespread throughout the range of the species excluding Tasmania and higher alpine areas. *Leucochrysum albicans* var. *buffaloensis* is restricted to Mt Buffalo and immediate environs, Victoria, and var. *tricolor* has three pockets of distribution, south-eastern New South Wales to north-eastern Victoria, south-western Victoria and scattered sites in Tasmania.

Within *L. albicans* subsp. *albicans*, var. *tricolor* is typically distinguished by the white inner involucral bracts and deep red to purple outer involucral bracts whereas vars *albicans* and *buffaloensis* both have yellow inner involucral bracts and brown outer involucral bracts. Var. *buffaloensis* is distinguished by having acutely tipped, broadly ovate to deltoid involucre bracts whereas var. *albicans* has elliptic to ovate involucre bracts with obtuse apices.

Some of these taxa seem trivially distinguished (Wilson 1960; Short 1999) with some herbarium material being tentatively placed, while subsp. *alpinum* appears to be consistently distinct. In an attempt to resolve the uncertainty apparent within the *L. albicans* complex, a study was undertaken to test the current classification using numerically-based morphometric techniques.

While carrying out this study variation was found in the leaf hairs amongst the different taxa. More detailed study aimed to examine the "stalked glandular hairs" of *L. albicans* and *L. molle* referred to by Short (1999) for any consistent patterns of variation that might support a revised taxonomy. Previous studies of micromorphological characters have found that shape and cell structure of mature carpopodia can be used to delineate taxa (e.g. Sundberg 1985) and these were examined for members of the complex. Scanning electron microscope studies were also undertaken to see if characters of the cypsela pericarp were informative.

Materials and methods

Character list and analysis

An initial scoring of 72 specimens using 60 morphological and longevity characters, including those mentioned in previous taxonomic treatments (e.g. Wilson 1960, 1992; Harden 1992, Short 1999), was carried out and subjected to analysis using the PATN program package (Belbin 2004). From this analysis, 14 characters were found to be informative and these were used to score 118 herbarium specimens. Previously published references have not separated leaf or involucre bract shape into their component attributes or made reference to other characters found to be informative during this study (Fig. 1; Table 1). These new characters combined with traditional diagnostic characters were used to carry out a morphometric analysis of the members of the *L. albicans* complex.

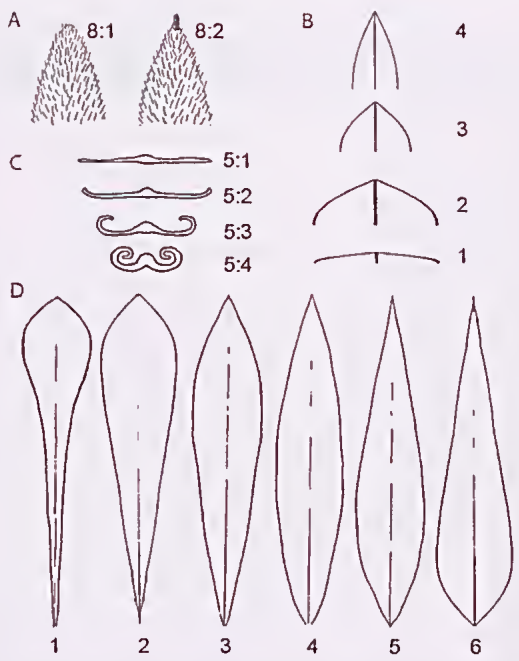


Figure 1: Schematic drawings of *(a)* leaf tip, showing the two states of character 8; *(b)* involucral bract lamina tip, showing the range in angles of both characters 12 and 13; *(c)* leaf margin, showing the range of curvature in character 5; *(d)* leaf and involucral shape, based on position of widest point along the length of the blade. Characters are numbered as in Table 1.

The 118 specimens examined in the analysis were sourced from the National Herbarium of Victoria (MEL), and the National Herbarium of New South Wales (NSW). Specimens from the herbarium of the Australian Daisy Study Group and collections made in the course of the study by a colleague, K. McDougall, have since

Table 1. Characters for morphometric study.

#	Character	#	Character
1	Life 1. annual 2. perennial	8	Leaf Tip 1. tip of leaf covered in hair 2. dark bald, mucronate tip
2	Leaf shape 1. spathulate 2. obovate 3. obovate / elliptic 4. elliptic 5. elliptic / ovate 6. ovate	9	Length of the lamina of the longest involucral bract (mm)
3	Width of widest part of longest leaf (mm)	10	Involucral bract ratio, length (mm) / width (mm)
4	Leaf ratio leaf length (cm) / leaf width (mm)	11	Involucral base shape 1. spathulate 2. obovate 3. obovate / elliptic 4. elliptic 5. elliptic / ovate 6. ovate
5	Leaf margin 1. flat 2. curved slightly inwards 3. recurved 4. revolute	12	Angle at tip of involucral bract lamina 1. flat to round 2. obtuse 3. 90° 4. acute
6	Leaf hair density 1. 0 - 10% (glabrescent - sparse) 2. 11 - 30% (light cobweb) 3. 31 - 60% (cobweb) 4. 61+% (woolly)	13	Angle at base of involucral bract lamina 1. flat to round 2. obtuse 3. 90° 4. acute
7	Leaf hair distribution 1. even hair density across dorsal and ventral surfaces 2. less hair on dorsal surface compared to ventral surface	14	Involucral bract colour 1. yellow 2. yellow and white 3. white

been incorporated into MEL's collections. The data were then analysed using PATN. The association matrix utilised the Gower metric. An ordination was produced using Semi-strong Hybrid Multidimensional Scaling (limit= 0.9) with two dimensions and a dendrogram was generated utilising flexible UPGMA (β=-0.1). Evaluation of characters was carried out using Principal Component Correlation (PCC) which generates the value and direction each character has on the points in ordination space (Belbin 2004).

Seedling germination

Plants were grown from seed at the nursery of the Royal Botanic Gardens Melbourne (RBGM). Diagnostic characters seen in the herbarium specimens were compared to seedlings as they were grown in the controlled environment of a glass house.

SEM preparation

Leaf samples were taken from the nursery-grown plants. Plants used were grown for eight weeks. Leaf samples were placed in 70% ethanol upon collection.

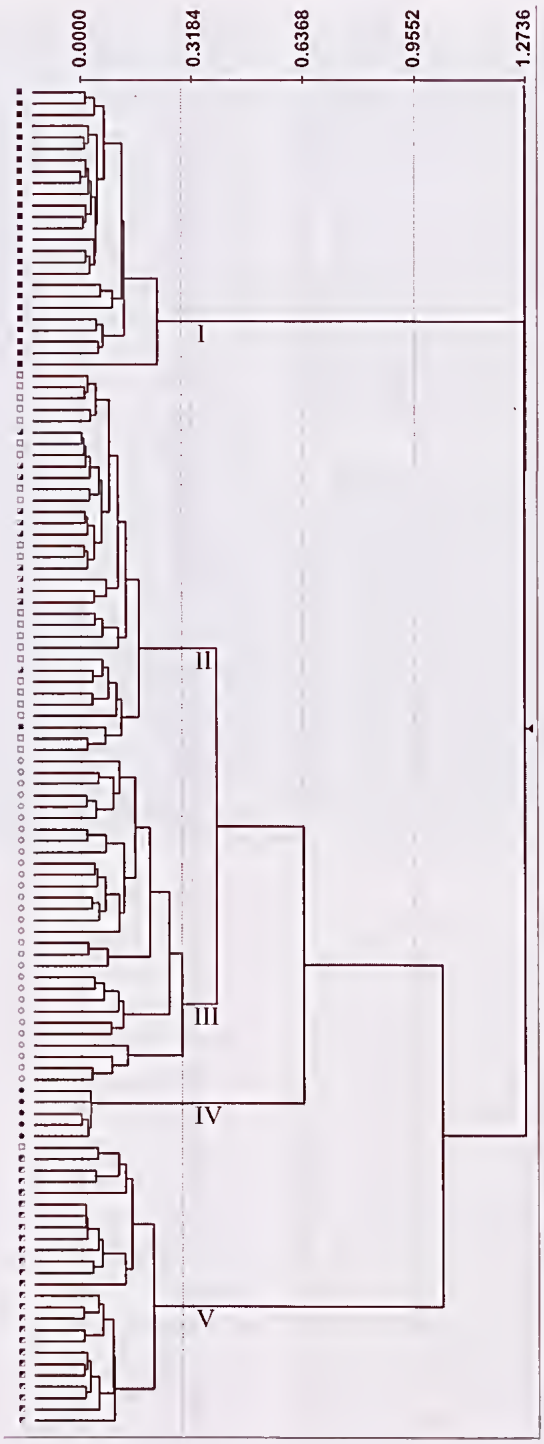


Figure 2: Cluster dendrogram of 118 specimens originally determined as *L. albicans, L. malle* and *L. graminifolium*. The 14 characters listed in Table 1 were analysed by Gower metric association with a flexible UPGMA (β=-0.1). At dissimilarity of 0.29 five groups are recognised I-V. Original determinations shown by symbols on left of dendrogram: *L .albicans* subsp. *alpinum* – solid squares; *L. albicans* var. *albicans* – open squares; *L. albicans* var. *buffalaensis* – squares, black in the lower right triangle; *L. albicans* var. *tricolar* – open circles; *L. graminifolium* – solid circles; *L. malle* –squares, black in the top left triangle.

Samples were then treated for 75 min in 90% ethanol then transferred to 100% ethanol and gently agitated for 24 hrs. Samples were then placed in fresh 100% ethanol and agitated for another 24 hrs. Critical Point Drying (CPD) of specimens was carried out the following day following the technique of Boyde and Wood (1969). Leaf tissue taken from the centre of the treated leaves was then placed on SEM stubs exposing both dorsal and ventral surfaces, then coated with gold using a Dynavac 'Xenosput' magnetron sputter coater. A Phillips XL 30 FEG Field Emission Scanning Electron microscope was used to examine the surfaces and capture the images.

From each of the taxa, two to three whole fruits, one with carpopodium exposed were placed on SEM stubs, desiccated, and sputter-coated with gold as described above.

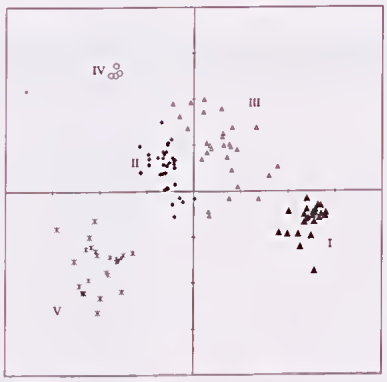


Figure 3: Ordination of 118 specimens originally determined as *L. olbicons, L. molle* and *L. graminifolium,* using Semi-strong Hybrid Multidimensional Scaling and a Gower metric assocation matrix for the 14 characters in Table 1. Groups as in Fig. 2.

Distribution maps

Distribution data were collated from AD, BRI, CANB, HO, MEL and NSW. Points with a geocode precision of less than 25 km were excluded.

Results

Dendrogram

The composition of the groups largely corresponds with current classification with five groups retrieved above a dissimilarity level of 0.29 (Fig. 2) with Group I comprising *L. albicans* subsp. *alpinum*; Group II, *L. albicans* var. *albicans*; Group III, *L. albicans* var. *tricolor*; Group IV, *L. graminifolium*; and Group V, *L. molle*. PATN could not distinguish *L. albicans* var. *buffaloensis* from var. *albicans*. The dendrogram pairs those specimens most similar to each other first and then progressively unites the groups. The less similar the specimens or groups are the later they will fuse. The first fusion is between Groups II and III, and then Groups IV, V and I successively join the cluster comprised of the other specimens.

Two specimens are apparently misplaced (based on the original determinations). One of these (*Adair s,n.*) originally held at MEL under *L. albicans* subsp. *alpinum* but classified by PATN with Group II (subsp. *albicans*) is a curious specimen, with the white and mauve involucral bracts of subsp. *alpinum* but with leaves narrower than normal and with a glabrous callous tip more characteristic of subsp. *albicans*. It may represent a hybrid between the two taxa, both being in the general area. If so, it is the only hybrid we encountered during the study. The apparently misplaced specimen in Group V (*L. molle*) was simply a misdetermination and this has now been rectified (*Short 3618*).

Ordination

In the ordination the stress was 0.0809, indicating a good fit between the two dimensional representation and the original data matrix. In the ordination space, more similar individuals are placed closer together. The same five groups as identified in the dendrogram (Fig. 2) remain resolved in the ordination (Fig. 3). Groups I (*L. albicans* subsp. *alpinum*), IV (*L. graminifolium*) and V (*L. molle*) are all well separated, while Groups II and III (*L. albicans* vars *tricolor* and *albicans* respectively) are closely contiguous but discrete. However, when character 14 (bract colour) was excluded from the analysis, groups III and II merged (not illustrated here). This indicates the closeness of these taxa and supports the retention of the bract colour that has traditionally been used to distinguish these two taxa. The composition of the groups is consistent with previously described taxa except in relation to var. *buffaloensis*. As with the dendrogram, there was no evidence of a discrete group for specimens that had been determined as var. *buffaloensis* and Group III

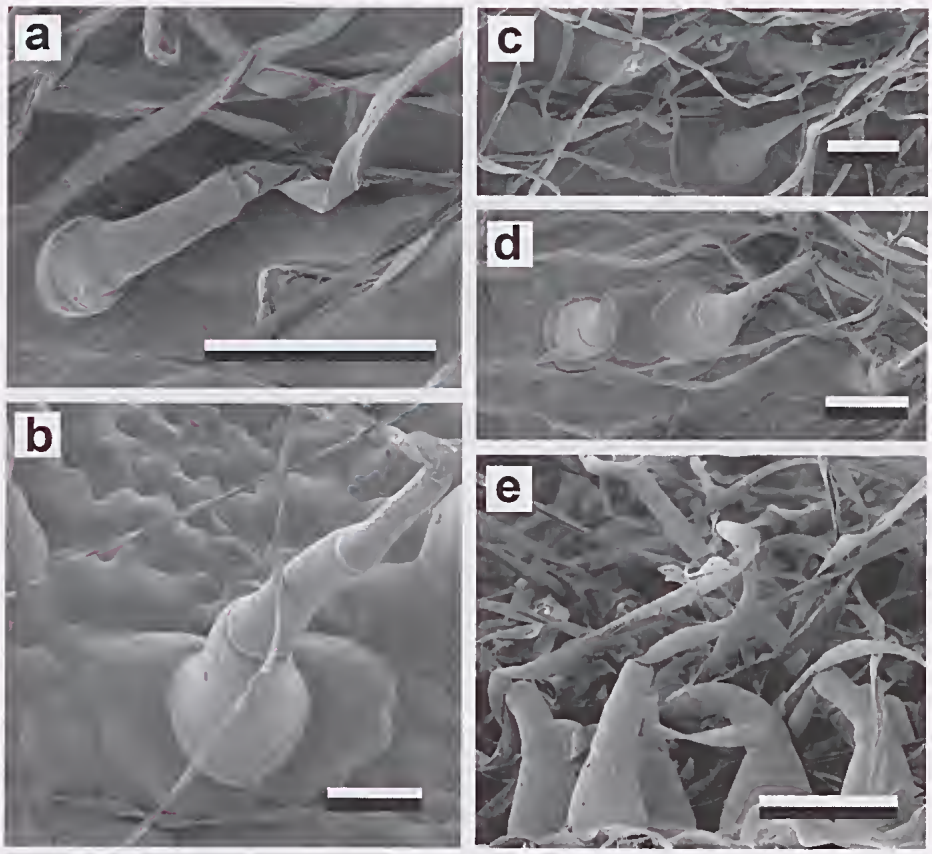


Figure 4: SEM images of the leaf hairs of the dorsal surface of leaves from (a) *L. albicans* subsp. *albicans* var. *tricalar*; (b) *L. malle*; (c) *L. albicans* subsp. *alpinum*; (d) *L. albicans* subsp. *albicans* var. *albicans*; (e) *L. albicans* subsp. *albicans* var. *buffalaensis*. The scale bars are 50 µm.

was a mixture of specimens determined as either var. *albicans* or *buffaloensis*.

Seedling characters

The early-adult leaves of the nursery-raised seedlings generally maintain the diagnostic features apparent on herbarium specimens. However the margins of leaves of all taxa were less strongly recurved than those of herbarium specimens, possibly a consequence of the more humid growing conditions in the nursery.

Leucochrysum molle had leaves with strikingly less dense indumentum, broader than those of var. *albicans* and much broader those of var. *tricolor*. The margins of the leaves of *L. molle* were also less recurved than those of *L. albicans* vars *tricolor* and *albicans*. Leaves of subsp. *alpinum* were densely covered in hair, had a distinctly spathulate shape, little to no recurving of the margin and lacked an obvious glabrous mucronate tip. All the other taxa grown have glabrous mucronate tips. There was little difference between vars *buffaloensis* and *albicans*, the former tending to have slightly broader leaves.

Eglandular leaf hairs

The leaf hairs of the taxa examined consist of inflated epidermal cells subtending one to five (usually three) stout basal cells above which is a filamentous ribbon-like extension composed of a number of elongated collapsed cells (Fig. 4). These hairs are found on all taxa examined. They belong to 'hair type B' sensu Drury & Watson (1966) and are common amongst members of the Asteraceae (Bessey, 1889; Bremer, 1994). *Leucochrysum molle* (Fig. 5b) has the largest hair basal cells of any of the taxa studied. They are at least three times larger than *L. albicans* var. *tricolor* (Fig. 5a). The

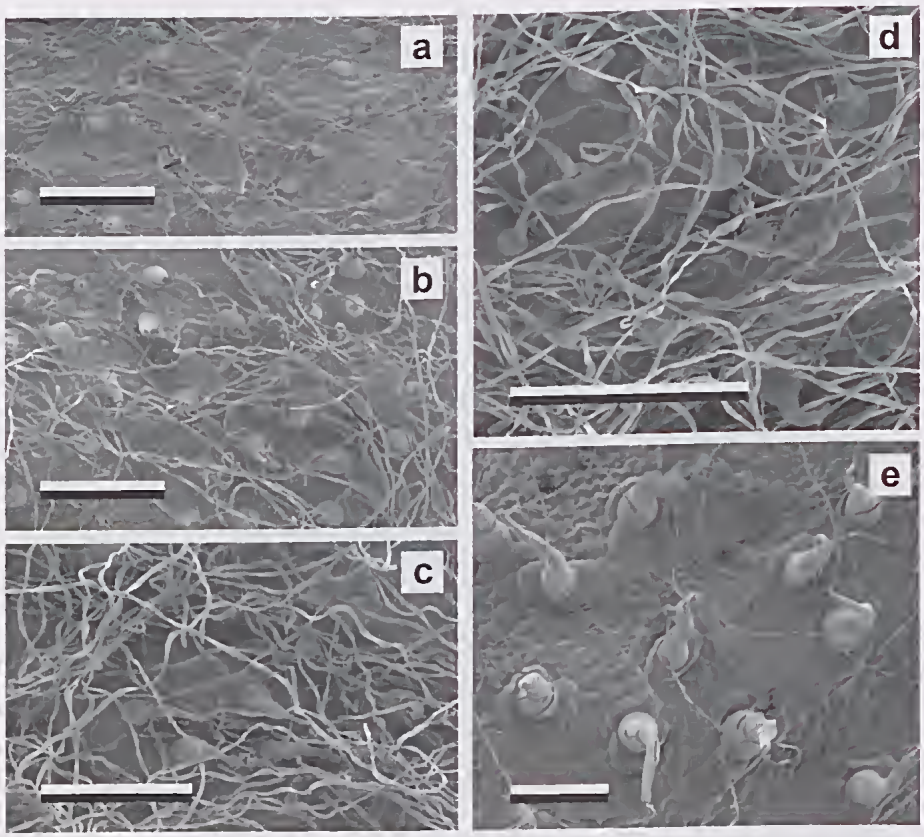


Figure 5: SEM images of the leaf hairs *af* the dorsal surface *af* leaves from (a) *L. albicans* subsp. *albicans* var. *albicans*; (b); *L. albicans* subsp. *albicans* var. *tricalor* (c) *L. albicans* subsp. *alpinum*; (d) *L. albicans* subsp. *albicans* var. *buffalaensis*; (e) *L. malle*. The scale bars are 200 µm.

size of the hair basal cells is proportional to the size of the epidermal cells in all the taxa.

The density of hairs differs between the taxa, ranging from the sparsely covered *L. molle* (Fig. 5e) to the densely lanuginose surface of *L. albicans* subsp. *alpinum* (Fig. 5c). The hairs of vars *albicans* (Fig. 6a), *tricolor* (Fig. 6b) and *buffaloensis* (Fig. 6d) are all similarly cottony in contrast. The hairs of the ventral surfaces have longer and thinner basal cells (Fig. 6) than those of the dorsal surfaces (Fig. 4). This difference is consistent across all taxa. The collapsed cells forming the tapering part of subsp. *alpinum* are more twisted than those of the other taxa (Fig. 5).

Glandular leaf hairs

The glandular hairs consist of four rows of paired cells (Fig. 7). The apical secretory pair of cells are larger than the supporting cells. These hairs are present on all the taxa examined. The general morphology of the glandular hairs is typical of many members of the Asteraceae (Hess 1938). Their distribution is sparse but consistent across the surface of the leaves (Fig. 6)

Pericarp surface

Although there is significant variation in the surface texture of the cypselas examined, both light and scanning electron microscopy has shown these to be of little taxonomic value within the complex. Surface textures examined ranged from smooth to distinctly colliculate, even within a taxon. A selection of SEM images indicating the range of surface textures of the *L. albicans* complex are presented in Figure 8, however, as stated, despite the substantial variation shown here, variability within taxa was too great for this character to

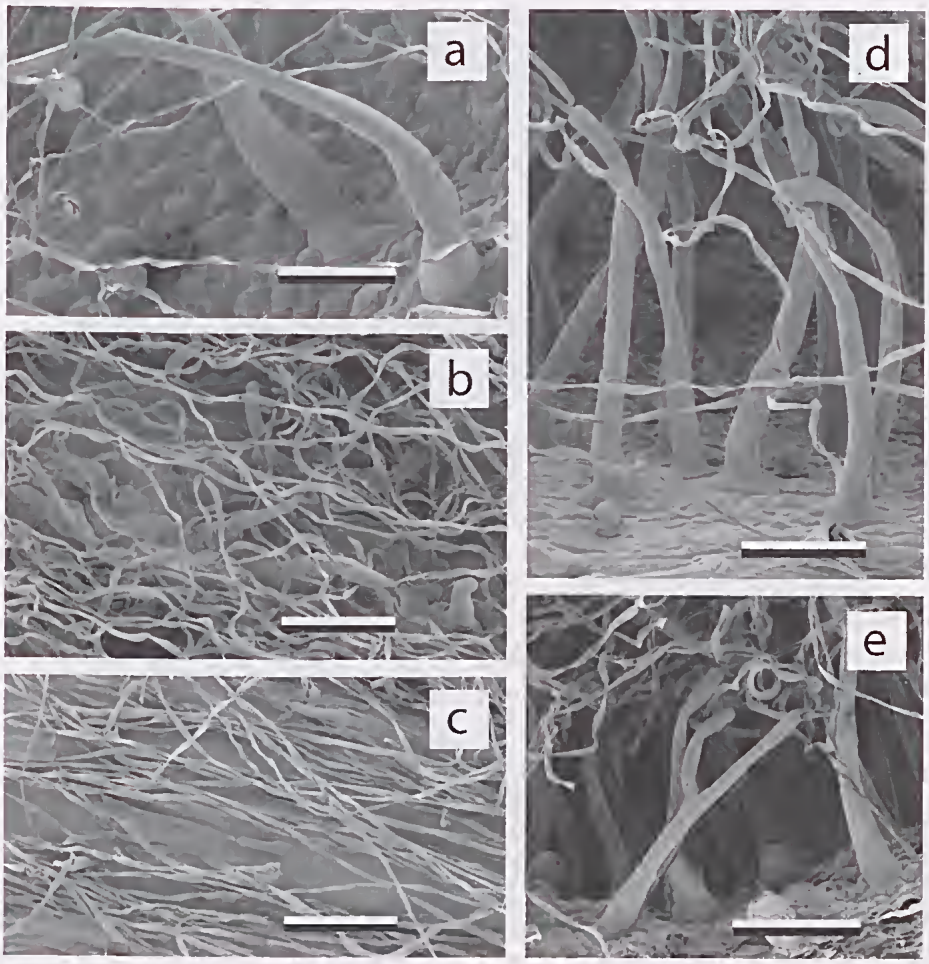


Figure 6: SEM images of the leaf hairs of the ventral surface of leaves from (a) *L. molle*; (b) *L. albicans* subsp. *alpinum*; (c) *L. albicans* subsp. *albicans* var. *tricolor*; (d) *L. albicans* subsp. *albicans* var. *albicans*; (e) *L. albicans* subsp. *albicans* var. *buffaloensis*. The scale bars are 100 µm.

be regarded as useful. The 2-celled myxogenic papillae regarded by Wilson (1992) as being diagnostic of *L. graminifolium* were not observed during this study.

The carpopodium

Scanning electron micrographs are presented of the carpopodia of members of the *L. albicans* complex. There is a distinct boundary between the carpopodium cells and those cells that make up the rest of the pericarp whether the pericarp has a papillose or flat surface (Fig. 9). Despite some variation in outline of the carpopodium (due to the position of the cypsela within the capitulum (Sundberg 1985)) the carpopodia of the different taxa exhibit basically the same morphology. The carpopodial cells are rectangular to oblong, and between 20 and 60 µm long.

Taxonomy

Morphological analysis, nursery trials and field examination support the reduction in members of the *L. albicans* complex from six to five, reducing *L. albicans* var. *buffaloensis* to synonymy under the typical variety. The recognition of var. *tricolor* is supported, although on the single criterion of the possession of white rather than yellow capitular bracts. The rank of variety is regarded as appropriate. *Leucochrysum albicans* subsp. *alpinum* is retrieved as a strongly supported group in the analysis. Its distinctiveness in the complex is shown

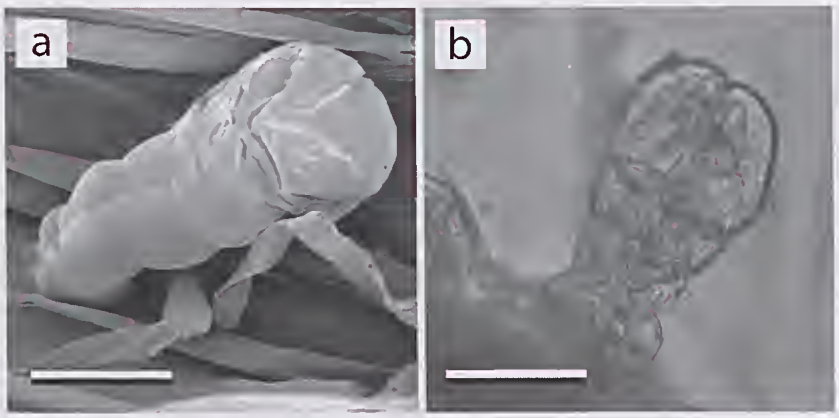


Figure 7: Images of the glandular trichomes on the (a) dorsal surface of a leaf from *L. albicans* subsp. *albicans* var. *buffaloensis* viewed through a light microscope; (b) ventral surface of a leaf from *L. albicans* subsp. *albicans* var. *tricolor* viewed using SEM. Scale bars are 20 µm.

in both the dendrogram and ordination to be as great or greater than either *L. molle* or *L. graminifolium* from 'core' *L. albicans* and it is proposed that it be recognised similarly at species rank.

The following key serves to distinguish the members of the complex.

Taxonomy and ecology

For full synonymy of the following names, see Wilson (1992).

Leucochrysum albicans (A.Cunn.) Paul G.Wilson, *Nuytsia* 8:442 (1992)

Helichrysum albicans A.Cunn. in Field, *Geog. Mem. New South Wales* 359 (1825). *Type*: Forest Land, Cox's River, 9 Oct. 1822, *A. Cunningham 71* (lecto: K; isolecto MEL2068831) *fide* Wilson 1960.

Leucochrysum albicans var. *albicans*

Leucochrysum albicans var. *buffaloensis* (Paul G.Wilson) Paul G.Wilson, *Nuytstia* 8:443 (1992); *Helipterum albicans* var. *buffaloensis* Paul G.Wilson, *Trans. Roy. Soc. South Australia* 83:170 (1960). *Type*: Mt Buffalo, Victoria,

Key to taxa

1	Leaves spathulate to broadly obovate, densely woolly; margin flat; apex lacking an obvious mucro or callus tip. Inner involucral bracts lanceolate to ovate, white, outer involucral bracts purplish to brown (especially apparent in early stages of capitulum development) ..... ***L. alpinum***
1:	Leaves obovate to filiform, cobwebbed to cottony or glabrescent; margin gently recurved to tightly revolute, apex with short glabrous mucro or callus tip. Inner involucral bracts suborbicular to broadly ovate or ovate, lanceolate to elliptic, white or yellow ..... **2.**
2	Annual herb; leaves lightly cobwebbed, obovate to oblancolate. Inner involucral bracts suborbicular to broadly ovate, rounded or truncate at base of lamina, yellow ..... ***L. molle***
2:	Perennial (although sometimes short-lived); leaves cottony or glabrescent, obovate to oblanceolate or linear to filiform. Inner involucral bracts obovate to ovate to lanceolate, white or yellow **3**
3	Leaves filiform, glabrescent; margin tightly revolute. Involucral bracts narrow-elliptic ..... ***L. graminifolium***
3:	Leaves obovate to oblanceolate or linear, cottony; margin recurved to revolute. Inner involucral bracts ovate to lanceolate, white or yellow ..... **4 (*L. albicans*)**
4	Inner involucral bracts yellow ..... ***L. albicans* var. *albicans***
4:	Inner involucral bracts white ..... ***L. albicans* var. *tricolor***

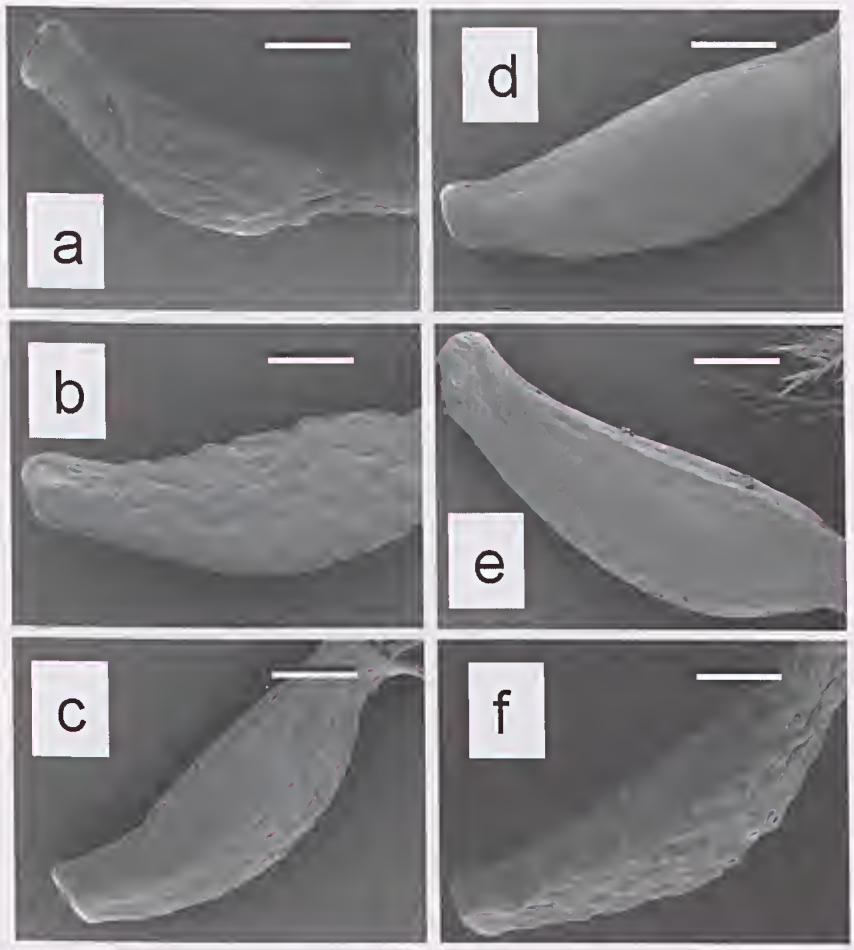


Figure 8: SEM images of cypsela pericarp detail of (a) *L. albicans* subsp. *albicans* var. *tricolar*; (b) *L. malle*; (c) *L. graminifolium*: (d) *L. albicans* subsp. *albicans* var. *buffalaensis*: (e) *L. albicans* subsp. *alpinum*; (f) *L. albicans* subsp. *albicans* var. *albicans*. Scale bars are 500 µm.

10 Nov. 1955, *E. Gauba* (holo: GAU) *fide* Wilson 1992.

Typically associated with dry open forests on shallow, rocky soils derived from a range of parent materials, but frequently sedimentary (mudstones, conglomerates etc.), but also occurring in subalpine heaths and, rarely, lowland grasslands or woodlands. Altitude range c. 100–1800 m. Qld, NSW, ACT, Vic. (Fig. 10a)

Representative specimens (specimens marked with asterisk used for SEM studies): **QUEENSLAND.** Ruby Ck near Stantharpe, 3.x.1992, *E.Salkin s.n.* (MEL2339313). **NEW SOUTH WALES.** Tenterfield, *C. Stuart s.n., s.d.* (MEL2161748); Near Tenterfield, xi.1874, *C. Stuart s.n.* (MEL2161778); 25 km S of Tenterfield, 29.ix.1987, *E. Salkin s.n.* (MEL2339315); Maanan Braak, 1883, *S.H. Carter, s.n.* (MEL2161764); Timbarra, *C. Stuart 136* (MEL); Cavan, near Yass, *J.S. Calvert, s.n., s.d.* (MEL); New England, *callectar unknown 30* (MEL); Hastings river, *H. Beckler s.n., s.d.* (MEL); New England, 1886, *R. Callie s.n.* (MEL2161790); **VICTORIA.** Wanga Park, Warrandyte State Park, *D.J. van Backel 88* (MEL); Mt Hedrick, *D.E. Albrecht 1952* (MEL292007); Wabanga Plateau State Park, *A.D.J. Piesse 393* (MEL685270); Hume Freeway, between Langwaad and Euraa, *R. Thamas 77* (MEL717321); Mansfield-Langwaad Rd, Euraa district, *R. Thomas 74* (MEL717324); The 8luff, *D.E. Albrecht 1555* (MEL1537304); Old Hume Highway, Wintan, *J. Strudwick 676* (MEL); 5 km ENE of Chiltern, *G. Jahnsan 25* (MEL1589399); 9.7 km W of Whitfield, *H.M. Jalley 17* (MEL2036568, S); Maunt 8uffala, Bald Hill, 20.ii.1963, *J.H. Willis s.n.* (MEL502500); Wall of China, Mt 8uffala, *R. Melville 2602* (K, MEL526618); Path ta Reeds Laakaut, Mt Buffala, *M.A. Tadd 250 & 329* (MEL559884, 562279);

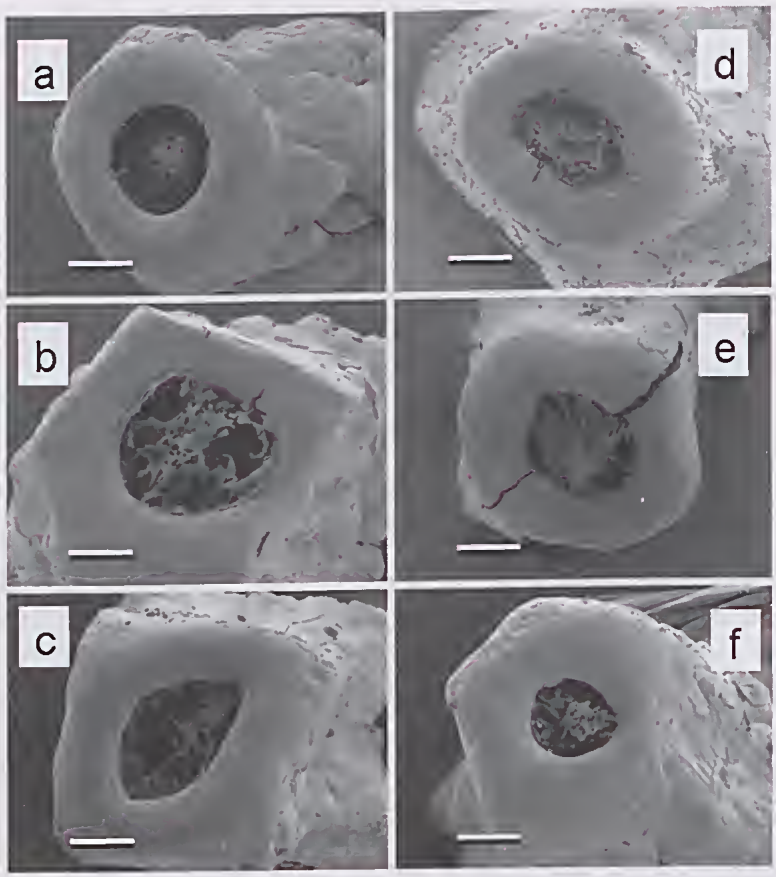


Figure 9: SEM images of carpopodia of (a) *L. albicans* subsp. *albicans* var. *tricolor*; (b) *L. albicans* subsp. *albicans* var. *albicans*; (c) *L. albicans* subsp. *alpinum*; (d) *L. albicans* subsp. *albicans* var. *buffoloensis*; (e) *L grominifolium*; (f) *L. molle*. Scale bars are 100 µm.

Mt Buffalo NP, *P.S. Short 1403* (MEL601904); Mt Buffalo, *S.T. Bloke 7344* (BRI, MEL67470B); Mt Buffalo, Chalet, *R. Thomos 76* (MEL717322); Mt Buffalo, *C. & D. Woolcock 1689* (MEL1524031); Mt Buffalo, iii.1931, *P.R.H. St John s.n.* (MEL2162059); Mt Buffalo, iii.1910, *W.R.A. Boker s.n.* (MEL2162060); Mt Buffalo NP, c. 200 m NE from Manfield Lookout, *N.G. Wolsh 5977* (MEL); Mt Howitt, 6.ii.1987, *E. Solkin s.n.* (MEL); Eildon-Jamieson Rd, 15 km from Jamieson, 7.xi.19B7, *E. Solkin s.n.* (MEL); Old Hume Hwy, Winton, *J. Strudwick 676* (MEL)*.

Leucochrysum albicans var. *tricolor* (DC.) Paul G.Wilson, *Nuytsia* 8:443 (1992)

Helipterum incanum var. *tricolor* DC., *Prodr.* 6:215 (1838). *Type*: Van Diemen [Tasmania], *R.C. Gunn 108* (holo: G-DC.), *fide* Wilson 1992.

A plant principally of grasslands and grassy woodlands on relatively fertile soils, often clays or clay-loams derived from basalt or dolerite, or at higher altitudes, from sedimentary parent material. Altitude range c. 100–900 m a.s.l. NSW, ACT, Vic., Tas. (Fig. 10b)

Representative specimens (specimens marked with asterisk used for SEM studies): **NEW SOUTH WALES.** 2 km NW of Mt Majura, *I.R. Telford 9890* (AD, CANB, MEL, PERTH); S of Tarago, 4.xi.19B4, *C.E. & D.T. Woolcock s.n.* (MEL); Between Blakney Ck and Bevendale, *E.M. Conning 6384* (CANB, MEL, NSW, PERTH, S); Hill End, sources of Lachlan River, *J. Louterer 2B* (MEL); Wellington, Dubbo, Tomingley, collector unknown 4B, *s.d.* (MEL); Braidwood district, *W. Boeuerlen 390* (MEL); Bombay Rd c. 500 m E of Shoalhaven R, *K.L. McDougoll 1204* (MEL); Kings Hwy, c. 1 km from Captains Flat turnoff, *K.L. McDougoll 1210* (MEL); Oallen Ford Rd, Windellama, *K.L. McDougoll 1213* (MEL); Snowy Mtn Hwy, 6 km E of Kosciuszko NP Boundary, *K.L. McDougoll 1220* (MEL). **VICTORIA.** Inverleigh Common, *E.G. Errey 4861* (MEL); Narrapumelap, *A.C. Beouglehole 61646* (MEL); Skipton,

Figure 10. Distribution maps using geocode data records from MEL, AD, CANB and HO for the species (a) *L. albicans* var. *albicans*; (b) *L. albicans* var. *tricolor*.

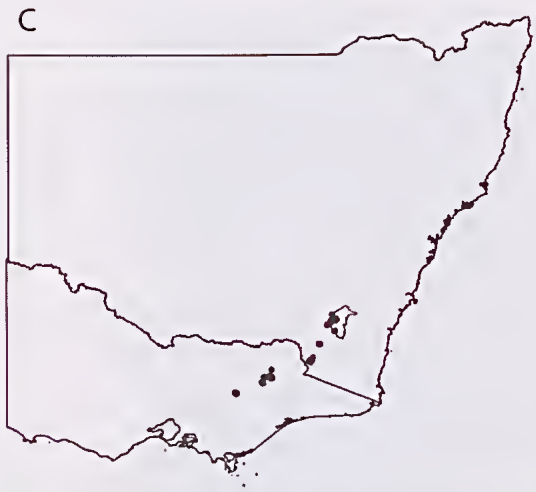
W. Whan s.n., s.d. (MEL). **TASMANIA.** Circular Head Bluff, *J. Milligan 551* (MEL); ca 6 km SE of Ross, *M.J. Brown 45* (HO, MEL); Middlesex Plains, *R.C. Gunn 513* (MEL); Circular Head Bluff, *J. Milligan 551* (MEL); Circular Head, *E. Oakden 115* (MEL); 'van Diemens', *R.C. Gunn 155* (MEL); 'Tasmania', *G.F. Story 32* (MEL); Rokewood, *N.G. Walsh 6619* (MEL)*; Mt Buffalo NP, 0.3 km from McKinnons Corner, *J.A. Jeones 1653* (CANB, K, MEL, NSW)*.

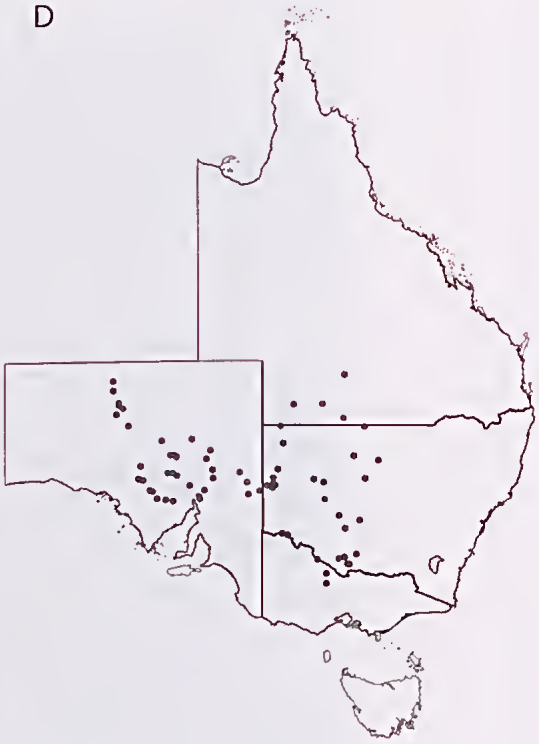
Leucochrysum alpinum (F. Muell.) R.J.Dennis & N.G.Walsh *comb. nov.*

Helipterum incanum var. *alpinum* F.Muell., *Rep. Pl. Babbage's Exped.* 14 (1859); *Leucochrysum albicans* subsp. *alpinum* (F.Muell.) Paul G.Wilson, *Nuytsia* 8:443 (1992). *Type*: Summit of the Australian Alps, *F. Mueller* (holo: MEL; iso: K, NSW).

Confined to treeless alpine and high subalpine heathlands and grasslands of the Australian Alps, usually on shallow soils derived from basalt, granite or sedimentary parent material. Altitude range c. 1500–2100 m a.s.l. NSW, Vic. (Fig. 10c)

Representative specimens (specimens marked with asterisk used for SEM studies): **NEW SOUTH WALES.** 20 km S of Picadilly Circus, *W. Bishop 580* (MEL292001, NSW, PRC); Between Seamans Hut and Mt Kosciuszko, *G. Stewort 751* (CANB, MEL1S82200, PERTH); Scabby Range, c. 2 km SSW of Mt Kelly, *F.E. Davies 1712* (CANB, HO, MEL1662341, NSW, PERTH); Seamans Hut, *N.G. Walsh 3397* (MEL2013660) Kosciuszko National Park, above Club Lake, *P.S. Short 4004* (MEL201469B); 4 km SW from Charlottes Pass, *M. Ito 96041* (MEL2030392, NSW); Summit of Mt Clarke, xii.1903, *A.J. Tadgell s.n.* (MEL2162240); Mt Kosciuszko, *R. Helms 121403* (MEL2162242, NSW); Snowy Mountains, *W. Baeuerlen 65* (MEL2162244); Mt Kosciuszko, *R. von Lendenfield 12* (MEL2162246); Mt Kosciuszko, *J. Stirling 23* (MEL2162247); Munyang Mountains, i.1874, *F. Mueller s.n.* (MEL2162249); Happy Jacks Rd, 2 km from Snowy Mtn Hwy, 2S.i.19B7, *E. Salkin s.n.* (MEL2339316). **VICTORIA.**: Mt Nelse summit, 11.ii.1977, *J.H. Willis s.n.* (MELS271S3); Eskdale Spur, Mt Bogong, *L.A. Craven 2127* (CANB, MEL537943); Mt Nelse, 8.i.1954, *C. Skewes s.n.* (MEL599S01); 1.2 km NE of Spion Kopje, 6.ii.19B0, *R.J. Adoir s.n.* (MEL678310); Watchbed Ck, *A.C. Beouglehole 15635* (MEL1S0S269); Mount Fainter, *A.C.*





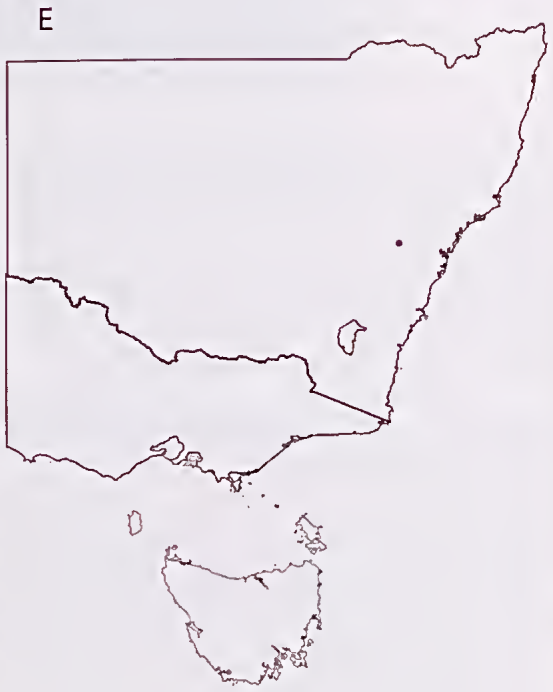


Figure 10 continued. Distribution maps using geocode data records from MEL, AD, CANB and HO for the species (c) *L. alpinum*; (d) *L. molle*; (e) *L. grominifolium*.

Beauglehole 22494 (MEL1505274); Bogong High Plains, i.1928, *A.J. Tadgell s.n.* (MEL2162252); Mt Hotham, i.1888, *C. Walter s.n.* (MEL2162253); Mt Hotham, *A.J. Tadgell 75* (MEL2162255); Summit, Mt Nelse North, 25.i.1997, *J.Greig s.n.* (MEL2339317); Bogong High Plains, c. 100 m SSW of Mt Nelse summit, *J.A. Jeanes 1640* (CANB, K, MEL2296401, N5W)*.

Leucochrysum molle (A.Cunn. ex DC.) Paul G.Wilson, *Nuytsia* 8:445 (1992).

Helichrysum molle A.Cunn. ex DC., *Prodr.* 6:194 (1838). *Type*: Molle's Plains, Lachlan River, New South Wales, July 1817, *A. Cunningham* (lecto: G-DC) *fide* Wilson (1960).

A species of semi-arid grasslands, open shrublands or woodlands, commonly with *Acacia* spp. or *Atriplex* spp. as emergents. Soils vary from sands, gibber to fertile clay-loams. Altitude range c. 100–200 m a.s.l. SA, Qld, NSW, Vic. (Fig. 10d)

Representative specimens (specimens marked with asterisk used for SEM studies): **SOUTH AUSTRALIA.** 3 km S of Pimba, *K. Wotonobe 326* (AD, MEL2027398, TI); Blinman, *Rumboll 1402* (MEL2160709). **QUEENSLAND.** 5 km SW of Eromanga, *P.S. Short 3618* (MEL220237); 58.2 km from Quilpie toward Charleville, *E.M. Conning 6244* (BRI, CANB, MEL714977, PERTH, S, US); E of Thargomindah, 1885, *G.L. Spencer s.n.* (MEL2160712). **NEW SOUTH WALES.** Steam Plains, c. 42 km NW of Jerilderie, *T. Jomes 371* (MEL291999, NSW); Sturt NP, 5 of Olive Downs, *W. Greuter 18506* (MEL1543002); 2 km W of Cobar, *P.S. Short 3077* (MEL1556462); Tibooburra-Noccundra,

195.8 km from Tibaaburra, *E. Salkin 762* (MEL2084703); Southern Barrier Range, 1893, *H. Deane s.n.* (MEL2160681); Warrega River, *E. Betche 51* (MEL2160683); Evelyn Ck, N of Barrier Range, 1887, *A. King s.n.* (MEL2160685); Between the Bogan and the Darling, 1877, *W.L. Marton s.n.* (MEL2160686); Darling River, 14.x.1860, *H. Beckler s.n.* (MEL2160689); Between the Lachland and Darling river, x.1885, *J. Buckner s.n.* (MEL2160691); Lachlan River, *G. Tucker 26* (MEL2160692); Silverton, xi.1884, *Harris, s.n.* (MEL2160693); Lower Edwards River, *G.A. Mein s.n., s.d.* (MEL2160695); Wilcannia, 1885, *M.B. Kennedy s.n.* (MEL2160698); Byrock, *E. Betche 7* (MEL2160699); Massgiel, 1885, *J. Brueckner s.n.* (MEL2160701); Barrier Range, 1889, *J.F. Irvine s.n.* (MEL2160702); Booligal, ix.1887, *A. Bell s.n.* (MEL2160706); Yandarlo via Wilcannia, *M.B. Kennedy 27* (MEL2160708); Deniliquin, 21,ix.1968, *F.J.C. Rogers s.n.* (MEL2231783). **VICTORIA.** Kerang Mitiamo Rd, 22.xi.2005, *D. Marshall s.n.* (MEL2293160)*.

Leucochrysum graminifolium (Paul G.Wilson) Paul G.Wilson, *Nuytsia* 8:444 (1992).

Helipterum albicans var. *graminifolium* Paul G.Wilson, *Trans. Roy. Soc. South Australia* 83:171 (1960). *Type*: Clarence-Wolgan Rd, New South Wales, 26 Feb. 1939, *W.F. Blakely, J. & W.J. Buckingham 3306* (holo: NSW; iso: AD, MEL).

A localised endemic growing on sandstone-ironstone outcrops (known locally as 'pagodas') in the Newnes-Capertee Valley area. Altitude range c. 800–1000 m a.s.l. NSW only. (Fig. 10e)

***Representative specimens*: NEW SOUTH WALES.** Clarence-Wolgan Rd, 31.xii.1939, *W.F. Blakely, J. & W.J. Buckingham s.n.*, (MEL, NSW); Wolgan Gap, 12.iv.1953, *L.A.S. Johnson s.n.* (NSW); Newnes Plateau, *J. Porter et al. 20119* (MEL291446, NSW); Glowworm Tunnel Rd, Wollemi National Park, *M. Kennedy et al. 59* (NSW).

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Recognition of a new species of *Pomaderris* (Rhamnaceae) in eastern Victoria based on morphological and chemical data

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Abstract

Pomaderris prunifolia A.Cunn. ex Fenzl is a variable and widespread species in south eastern Australia. Within the current circumscription of this species is a variant recognised by its distinctive leaf morphology. This study has determined that this variant should be recognized as a separate species, based on both leaf morphology and phenolics. The study of morphology employed both conventional hand measured methods and landmark shape analysis. The new species, *Pomaderris briagolensis* Messina is described and illustrated, and its conservation status discussed.

Keywords: taxonomy, *Pomaderris*, Rhamnaceae, morphometrics, Victoria.

Muelleria 28(2): 136-145 (2010)

Introduction

The genus *Pomaderris* (Rhamnaceae) is centered in Australia, where, at present, 68 species are recognised, five of which are also found in New Zealand. A further three species are endemic to New Zealand (Moore 1986; Walsh 1999, 2008, in ed.). This genus is considered an old group in the Australian flora, distributed across south-western, southern and eastern Australia, and is most diverse in eastern Australia (Ladiges *et al.* 2005). Much of the taxonomy of this genus has been clarified recently, with numerous new species described from eastern Australia (Walsh 1988, 1989, 1990a, 1990b, 1992, 2008; Ross, 1990; Walsh & Coates 1997; Millott & McDougall 2005; Kellermann *et al.* 2006). Many of these studies have identified rare, and/or narrowly endemic species, particularly in south-eastern New South Wales and eastern Victoria.

Pomaderris prunifolia A.Cunn. ex Fenzl is distributed through eastern Australia, mainly east of the Dividing Range, from Stanthorpe in south-eastern Queensland, south to the Grampians in western Victoria. There are currently two recognised varieties of *P. prunifolia*; var. *prunifolia* in Australia and var. *edgerlyi* (Hook.f.) L.B. Moore, a prostrate shrub endemic to New Zealand (Allan 1961). The distinctive habit of var. *edgerlyi*, and its wide geographic separation from the typical variety suggests an elevation in taxonomic rank is warranted, but it was not included in the present study.

This study investigates a population currently referred to as *Pomaderris* sp. aff. *prunifolia* (Briagolong) (Walsh & Stajsic 2007), and mentioned in a note under *P. prunifolia* var. *prunifolia* in Walsh (1999). It shares with *P. prunifolia* generally similar indumentum and floral characters but is reported to differ from it, particularly in leaf shape, size, margin features and texture. At present this variant is only known to occur in a single catchment area near Briagolong in eastern Victoria. At one location, both 'typical' *P. prunifolia* and the Briagolong variant

occur together with no intermediates having been observed. This study aims to investigate whether the variant warrants formal taxonomic recognition, and if so, at what level it is most appropriately recognised. For simplicity, it is referred to hereafter in this paper as the 'Briagolong variant'.

In establishing whether the Briagolong variant diverges significantly from specimens referred to the widespread, variable *P. prunifolia*, several techniques were used. These included a range of morphological analysis techniques, and chemical (flavonoid) analysis of the leaves.

Over the past two decades, several methods for describing shapes mathematically utilising advances in computer technology have been developed as an alternative to using traditional morphological methods, such as linear measures of length and width. These computer-based methods appear to have great potential for analysis of leaf shape in aiding species delimitation, especially where leaf shape is an apparently strong character, such as in some species of *Pomaderris* (e.g. Walsh 1999). These methods are capable of rapidly describing complex shapes in great detail, allowing characters that are usually difficult to measure by hand to be easily included in analysis (West & Noble 1984; Ferson *et al.* 1985). Along with a traditional morphometric, multi-character analysis of herbarium specimens, computer visualisation of leaf shapes using both a traditional linear analysis, and a landmark analysis technique developed by Rohlf (2003) were employed to detect any distinct entities within *P. prunifolia*. As well as corroborating the morphometric analysis, the shape analyses were used to test the assertion that as landmark-type techniques include more complex measures in analysis they will produce more accurate results as shown by Kincaid and Schneider (1982), West and Noble (1984) and Ferson *et al.* (1985).

Landmark analysis is similar to traditional analysis, as linear measurements are made from designated points. However, in this method, multiple measures are used simultaneously, rather than one at a time (McLellan & Endler 1998). This method also differs from traditional analysis as the relative positioning of landmarks is measured rather than the simple distance between landmarks (Jensen 1990). Landmarks are based on biologically homologous points on leaves. This allows biological relationships to be established relatively easily from data (Hammer 2002; Jensen *et al.* 2002). Landmark analysis can be correlated to original measurements, allowing highly localised changes in shape to be detected. Consequently, differences in certain structures are detected, rather than broad differences in overall shape (Rohlf & Marcus 1993).

Methods

Herbarium specimens, along with freshly collected material were used in this study. Morphology was analysed by two methods; firstly by traditional manually measured analysis of overall morphology based on herbarium material across the range of the species, and also by computer-based morphometric analysis of leaves, using freshly collected material. An analysis of leaf flavonoids was also performed using freshly collected material. Seedlings were grown in uniform glasshouse conditions at the La Trobe University, Bundoora, Victoria. Field observations and herbarium database records were used for additional information. Collection sites were derived from herbarium specimens and further field searches.

Collections

For landmark and flavonoid analysis populations of *P. prunifolia* were sampled throughout Victoria across a wide range of habitat types in an attempt to cover the range of variation in this species (Appendix 1). Victoria contains populations in most broad habitat types in which *P. prunifolia* occurs, from coastal areas through to sub-alpine areas and from dry to mesic forest types. The Briagolong variant was collected from five sites along Freestone Creek, north-west of Briagolong township. These represent the only known localities of the entity. Voucher specimens of collections were lodged at the La Trobe University herbarium (LTB).

Morphology

Hand measured data

Quantitative and qualitative measurements were manually scored using herbarium material; these measurements included length and width measurements of organs as well as derived ratios, number of veins and flowers, and ordered qualitative measures including shape and texture measures (Table 1).

Table 1. List of manually scored morphological characters.

Character type	Character description
Qualitative	leaf shape (SHAPE): ovate (0), elliptic (1), obovate (2)
	leaf margin (MARG): toothed (0), sinuate (1), entire(2)
	leaf apex (APEX): acute (0), obtuse (1), emarginated (2)
	adaxial leaf hair distribution (HAIRD): dense cover (0), low-moderate cover (1), absent (2)
	abaxial leaf hair type (HAIRB): stellate (0), stellate and simple on veins (1), stellate and simple all over (2)
Quantitative	leaf length (LLEN): mm
	leaf width (LWID): mm
	number of veins (VEINS): numeric
	stipule length (STIPL): mm
Derived ratios	leaf width/leaf length (LWTOL)
	number of veins/leaf length (VETOL)

The five largest leaves of each specimen were chosen for analysis, ensuring as much as possible that only mature leaves were selected. The mean of these five leaves was used for numerical analysis. The mean of two inflorescences per specimen was used to calculate floral characters, as most specimens contained fewer than five inflorescences. All specimens held by the National Herbarium of Victoria (MEL) and subsequent fresh collections were analysed. A list of these specimens is available from the authors.

Computer-based analysis

From each field collection, the ten best (most intact) leaves were removed from the point of attachment of the petiole and stem of five branches per population. Leaves were kept flat between sheets of cardboard for 24 hours before taking a black and white photocopy of the adaxial surface of each set of fifty leaves. This photocopy was then scanned into a computer using a CanoScan N670U scanner at 400dpi resolution. Adobe Photoshop v.7.0 was used to manipulate the images; making outlines clear by adjusting the image threshold, and arranging them vertically.

Traditional analysis was performed using silhouettes obtained using Photoshop. These were printed and captured by the program MorphoSys v. 1.26 (Meacham & Duncan 1991) using a Mintron CCD video camera. On each image six points were marked; 1 — petiole tip, 2 and 6 — petiole attachment to lamina surface, 3 and 5 — widest point, and 4 — the leaf tip. These points were marked to allow leaf area (AREA), perimeter (PERIM), lamina length (LLEN), lamina width (LWID), distance to widest point (DWID), petiole length (PETI), leaf length to width ratio (LL:W), distance to widest point to length ratio (LD:L), and degree of leaf curvature (CURV) to be measured. MorphoSys records leaf outlines as a series of chain codes. These were transformed into XY coordinates for use later. A program was written (T. Whiffin unpubl.) to perform this transformation into XY coordinates, with landmarks two and six being the start and end point of the outline (removing the petiole).

Landmark configurations recorded in MorphoSys were also used in landmark analysis by tpsSuper (Rohlf 2003). The tpsSuper program superimposes leaf images on each other, so before analysis leaf images were manipulated so that they were lying flat on the X axis. A further program was written (T. Whiffin unpbl.) to align the leaf apex (landmark 3) on the X axis, putting the leaf base (the point between landmarks 1 and 5) on the other end of the X axis. Landmark 1 was not included in this analysis as the procedure analyses lamina shape. Once images were aligned on the X axis, tpsSuper was used to obtain a landmark consensus configuration for each individual. Text files produced for plant configurations were grouped together into populations and saved as .tps files. These were re-entered into tpsSuper giving a consensus shape analysis for each population.

Flavonoid analysis

Flavonoid analysis was performed using leaves of five individuals per population. Depending on leaf size,

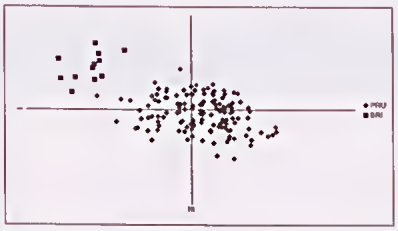

Figure 1: Ordination of hand measured morphological data (GM PCA). Stress: 0.109. Axis I and III shown.

between ten and twenty leaves were collected from each of the five individuals and air-dried in paper bags. Leaf material used in the morphological and chemical analysis was taken from the same plants. Only fresh material was used in this study, as herbarium material does not always give satisfactory results. Fungal action and oxidization during drying stages can change some of the chemical constituents found in old leaves (Markham 1982). Flavonoid extraction and separation techniques followed the procedures of Mabry *et al.* (1970) and Markham (1982). Leaf extracts were run in two dimensions on Whatman 3MM (46 X 57 cm) chromatography paper, firstly using t-butanol:acetic acid:water 3:1:1 (TBA) and secondly using 15% aqueous acetic acid (HOAc).

Once dried, phenolic compounds were viewed using long-wavelength ultraviolet light. Ammonia vapor was used to further enhance spot differentiation. Relevant spots were marked and given a number based on their relative position and colour, as seen on composite sheets. Each population was then scored for presence or absence of each constituent. No attempt was made to chemically characterise any compound, or to determine quantitative amounts of compounds.

Numerical analysis of morphology and phenolics

Multivariate analysis was performed to analyse data using PATN (Belbin 1987). Cluster and ordination analysis were performed on range-standardised data. The distance matrix was calculated using the Gower Metric (GM). This was input into cluster analysis using unweighted pair-group method using arithmetic averages (UPGMA) to produce dendrograms. Ordinations were performed using principal coordinates analysis (PCA).

Results and Discussion

Morphology

Hand measured data

Manually measured morphological characters are able to separate the Briagolong variant from typical *P. prunifolia* (Fig. 1). There is one individual of *P. prunifolia* that approaches the cluster of the Briagolong variant specimens. This specimen represented the highest recorded altitudinal occurrence of the species, (near Mt Arbuckle at approximately 1300m), and it could be anticipated that it possessed atypical characteristics. It is a small leaved specimen, presumably a reflection of the exposed nature of the site. In other respects (e.g. leaf shape, upper surface texture) it did not visually match specimens of the Briagolong variant. This analysis only included vegetative characters as initial assessment of the characters showed insufficient variation within the dataset to separate the two entities. This is not an uncommon situation in closely related species of *Pomaderris* (e.g. Walsh 1999).

Leaf dimension and shape data

Using MorphoSys to generate linear measures of leaf shape found three main clusters, again showing populations of the two entities to be separate. However this analysis split the typical form of *P. prunifolia* into two groups, with one group clustering more closely with the Briagolong variant (Fig. 2). Here the problems with using size as a surrogate of shape can be seen as *P. prunifolia* cannot be separated from the Briagolong variant based on linear measures alone. Furthermore, this result may not be biologically meaningful, as leaf size is generally not thought to be independent of environment (Kincaid & Schneider 1982; Dickinson *et al.* 1987; Rohlf & Bookstein 1987).

Landmark analysis

Pomaderris prunifolia and the Briagolong variant are shown to be very distinct groups by landmark TPS analysis (Fig. 3). Multivariate analysis shows all populations of the Briagolong variant to be very similar to each other, and different from *P. prunifolia*. This supports the contention that the Briagolong variant deserves taxonomic recognition based on leaf shape, as there is non-overlapping variation between it and *P. prunifolia*.

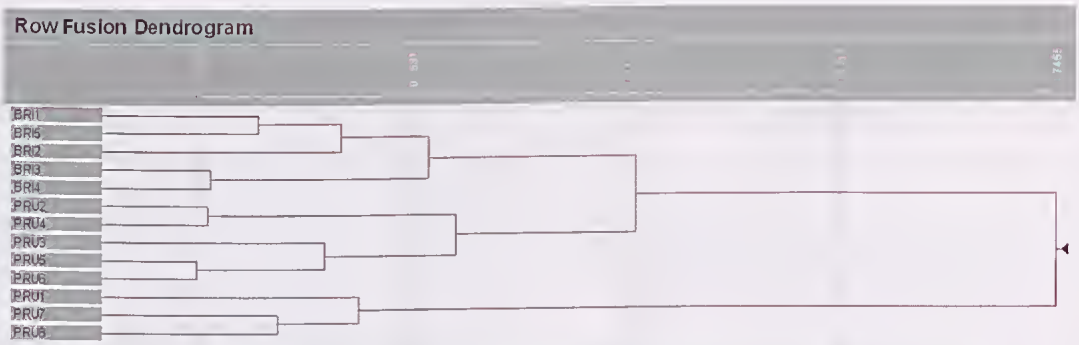

Figure 2: Cluster analysis (GM UPGMA) of morphological data using computer-based linear analysis. Names refer to populations (see appendix 1).

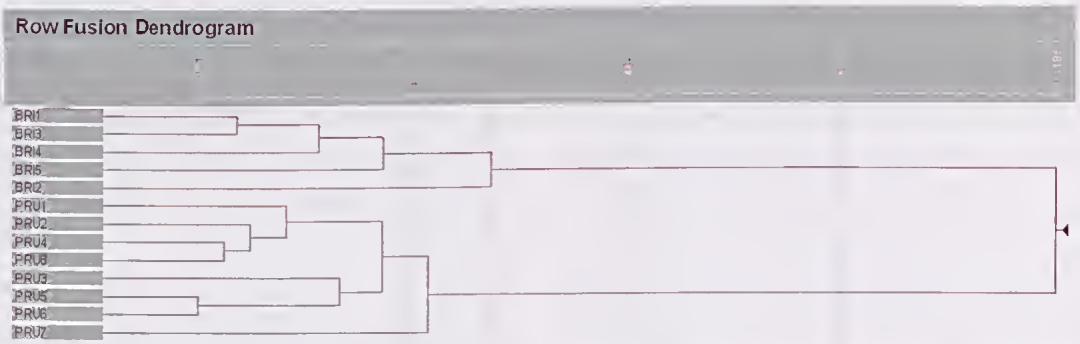

Figure 3: Cluster analysis (GM UPGMA) of TPS landmark analysis of leaf shape. Names refer to populations (see Appendix 1).

Use of the widest point on each side of the leaf blade as a landmark has been criticised by Jensen (1990) as not being based on genuine biologically homologous points, as these points may vary from leaf to leaf. However, they have been used as landmarks in this study as the leaves of the taxa investigated approximate to simple convex curves, making the widest point on each leaf unambiguous and clearly defined. This would be an inappropriate method if leaves were strongly lobed or toothed, with several possible locations on leaves being considered the widest point.

The landmark analysis was able to better discriminate between taxa than traditional length and width measures alone. It should be noted that tpsSuper is one of several methods available to analyse complex shapes. Other programs that use non-linear measures of shape were used during this study, but these produced results that were not readily reconciled with overall appearance of the specimens, or their provenance (data not shown). For further comments and comparisons of the various morphometric techniques see Premoli (1996), McLellan & Endler (1998) and Jensen *et al.* (2002).

Flavonoid analysis

Analysis of leaf phenolics shows differences in the presence of compounds in the two entities (Table 2). Major constituents have been shown to be consistently present in both entities, with variation shown in less common compounds: 'F' and 'N' being unique to the Briagolong variant and 'B', 'K', 'L' and 'M' being found only in typical *P. prunifolia*. Multivariate analysis (Fig. 4) of leaf flavonoid composition shows the Briagolong variant clearly separated from *P. prunifolia*, further supporting the separation of these two entities at specific rank. Flavonoid analysis may be a good method for validating the taxonomic status of other morphologically similar species of *Pomaderris*, but

Table 2. Presence/absence of flavonoid compounds in each population sample. Presence of compounds is denoted by X.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
bri1	X		X			X	X	X	X	X				X
bri2	X		X			X	X	X	X	X				X
bri3	X		X	X	X	X	X	X	X	X				X
bri4	X		X			X	X	X	X	X				
bri5	X		X	X	X	X	X	X	X	X				
pru1	X		X	X	X		X	X	X	X	X	X	X	
pru2	X		X	X	X		X	X	X	X	X	X		
pru3	X		X	X	X		X	X	X	X		X		
pru4	X	X	X	X	X		X	X	X	X	X			
pru5	X	X	X	X	X		X		X	X	X	X		
pru6	X	X	X	X	X		X		X	X	X	X	X	
pru7	X		X	X	X		X	X	X	X	X	X		
pru8	X		X	X	X		X	X	X			X		

clearly further work is required to test this across the genus. As far as we are aware it has not previously been employed in taxonomic studies of the genus.

Seedling trials

Although only a limited amount of seed was available for growth trials and results were not able to be statistically evaluated, seedlings of both typical *P. prunifolia* and the Briagolong variant, derived from several populations of each and grown under the same conditions, bred true to type and soon developed the characteristic shape and surface characteristics of the parent plants.

The strong separation shown in the above analyses, and the distinctness in the field when the two entities occur sympatrically and the uniform seedling characteristics suggest that the Briagolong variant is most appropriately recognised as a distinct species and is formally described below.

Taxonomy

Pomaderris briagolensis Messina *sp. nov.*

P. prunifolia *affinis sed foliis minoribus obovatis integris ad apicem truncatis vel emarginatis, pagina supra saepe glabra et nitida differt.*

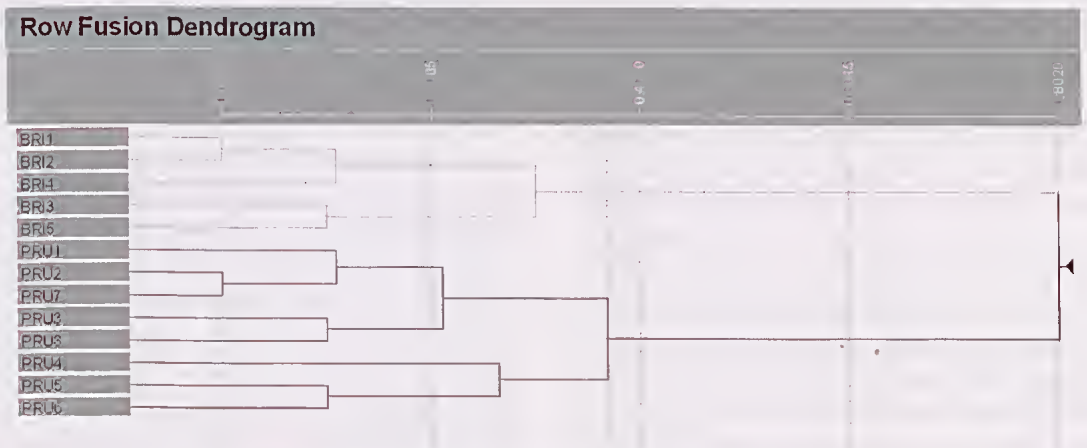

Figure 4: Cluster analysis (GM UPGMA) of leaf phenolic data. Names refer to populations (see Appendix 1).

Figure 5: *Pomaderris briagolensis*. a flowering branch x 1; b flower x 8; c leaf, adaxial view, x 3; d leaf, adaxial indumentum, x 8; e leaf, abaxial indumentum, x 8; f fruit x 8 (a–e from *Kilgour 315*; f from *Walsh 6167* (MEL).

***Type*:** Victoria. Briagolong, Johnston's Flat campground, 8.x.2006, *A.Messina 42* (holo: MEL 2309916).

Shrub to 2 m high. *Branchlets* pubescent with dense rusty stellate hairs, indumentum persisting to older stems of current season's growth. *Stipules* linear-filiform to triangular 1–5 mm long, brown with whitish stellate hairs, commonly persisting after leaves have fallen. *Petiole* 4–9 mm long, pubescent with dense covering of rusty stellate hairs. *Lamina* obovate or c. oblong, 12–24 mm long, 6–10 mm wide; apex obtuse to truncate or slightly emarginate; base cuneate, margins entire; lamina penninerved with 5–10 pairs of lateral veins, slightly impressed on upper surface, raised on lower surface; upper surface glossy *in vivo*, glabrous to sparingly simple-hispid; lower surface of lamina densely covered with white stellate hairs, with larger rusty stellate hairs scattered across lamina and covering veins and margin. *Inflorescences* compact, paniculate, terminal or axillary, pyramidal, to 40 mm long and 30 mm diameter, with c. 20–60 flowers. *Pedicels* 1–2 mm long, pubescent with moderate to dense covering of whitish stellate hairs. *Bracts* 2–3 mm long, 0.75–1.8 mm wide, stellate-velutinous on outer surface, sparsely sericeous on inner surface, deciduous, falling before anthesis. *Hypanthium* cup-shaped, 1–1.5 mm long, densely covered with white stellate hairs and longer simple hairs. *Sepals* 1.5–2 mm long, 0.8–1 mm wide, acute at apex, outer surface covered by an indumentum of whitish stellate hairs and longer white and rusty simple hairs, inner surface glabrous and yellow with a raised midline.

Petals absent. *Disc* not apparent. *Stamens* alternate to sepals; filaments 1.5–2.2 mm long; anthers oblong, 0.5–1 mm long. *Ovary* inferior, 1–1.5 mm diam., summit pubescent. *Style* 0.7–1.7 mm long, 3-branched from near midway. *Schizocarps* ellipsoid, 2.5–3 mm long, 1.5–2 mm diameter, splitting into 3 nutlets at maturity; operculum on inner face of each nutlet membranous, c. half as long as nutlet, apex acute. *Seeds* flattened-ellipsoid, 1.5–2 mm long, shining brown with a small apical aril.

***Specimens examined*: VICTORIA**. Sportsman Ck Natural Feature Zone, 26.ix.19B4, *A.C.Beauglehole 77354* (CHR, HO, MEL); Freestone Ck Natural Feature Zone, 27.ix.1984, *A.C.Beauglehole 77394* (CANB, MEL); Banks of Freestone Ck, opposite Winkie Ck Tk, 14 km N of Briagolong, 24.x.19B2, *R.A.Kilgour 315* (MEL); Freestone Ck, approx. 2 km north of Briagolong, 24.iii.2005, *A.Messina 1* (LTB); Freestone Ck, approx. 20 km north of Briagolong, 24.iii.2005, *A.Messina 12* (LTB); Freestone Ck, approx. 21 km north of Briagolong, 24.iii.2005, *A.Messina 14* (LTB); Freestone Ck, approx. 22 km north of Briagolong, 24.iii.2005, *A.Messina 17* (LTB); Freestone Ck, approx. 20.5 km north of Briagolong, 24.iii.2005, *A.Messina 19* (LTB); Briagolong, Lees Tk, near Freestone Ck, 7.x.2006, *A.Messina 38* (MEL); Freestone Ck, 2 km N of Briagolong, 25.iv.19B9, *N.G.Walsh 2396* (CANB, MEL, NSW); Briagolong, beside Freestone Ck, 15.xii.2004, *N.G.Walsh 6167* (K, MEL).

***Distribution and conservation status*:** Known from populations along the Freestone Creek catchment near and upstream from Briagolong in eastern Victoria. It occurs in two Natural Feature Zones, with a known area of occupancy of approximately 15 km^2. Within this area it is locally abundant, with populations ranging from 2–300 individuals. It is recommended for classification as rare (2RC- V66, C67- Freestone Creek NFZ), applying the ROTAP criteria of Briggs and Leigh (1996). Applying the criteria of the IUCN Red List (IUCN 2001), *P. briagolensis* is recommended for classification as critically endangered (CR B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v)).

***Habitat*:** *Pomaderris briagolensis* occurs on steep slopes toward valley floors down to alluvial flats, on rocky soils consisting of gravel, sand, silt and clay (LCC 1982), in *Eucalyptus*-dominated woodlands and riparian shrublands. Associated species include *Eucalyptus bridgesiana* R.T.Baker, *E. macrorhyncha* F.Muell. ex Benth., *E. melliodora* A.Cunn. ex Schauer, *Acacia floribunda* (Vent.) Willd., *Cassinia longifolia* R.Br., *Kunzea ericoides* (A.Rich.) Joy Thomps. *sens. lat.* and *Prostanthera rotundifolia* R.Br. The altitude range is c. 70–200 m. At the site nearest the Briagolong township, *P. briagolensis* occurs with at least six other species of *Pomaderris* in a mixed shrubland. Communities in which multiple species of *Pomaderris* occur are known in several sites in south-eastern New South Wales and eastern Victoria. As at the Briagolong site, these sites share characteristics of relatively low altitude, rocky substrates and close proximity to watercourses within otherwise rather dry country.

***Notes*:** Originally included in *P. prunifolia* var. *prunifolia* due to its similar indumentum and distribution and general floral characters. However, it can be distinguished by its smaller, obovate, entire leaves which have obtuse to truncate or emarginate apices, and its generally glabrous and glossy upper leaf surface.

Of species that occur in eastern Victoria, the foliage of *P. briagolensis* is most similar in shape to that of *P. pauciflora* N.A.Wakef., but the leaves are larger, not distinctly recurved at the margins, lack simple hairs on lower leaf lamina, and the simple hairs on the upper lamina are absent or much sparser.

Acknowledgements

We are grateful to Cam Beardsell for supplying seeds of *P. prunifolia*, Christine and Tony Richards for their kind hospitality in Maffra, Catherine Nield for assistance with fieldwork, Max Bartley, Trevor Phillips and Edgar Sakers for technical support, Drs Pete Green, John Morgan, Bob Parsons and Jodi Price for offering comments on drafts of this paper, David Cameron for discussions regarding conservation status, and to Anita Barley for the accompanying illustration of *P. briagolensis*.

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Appendix 1. Collection sites of *P. prunifolio* and the Briagolong variant. All specimens held at LTB.

Species collected	Collector	Location	Lat/Long	Date
P. sp (bri1)	A. Messina 1 & N.G. Walsh	Briagolong – Freestone Creek	37°49'45" S 147°4'9" E	24/3/0S
P. sp (bri2)	A. Messina 12 & N.G. Walsh	Culloden – Freestone Creek	37°42'42" S 147°8'13" E	24/3/05
P. sp (bri3)	A. Messina 14 & N.G. Walsh	Culloden – Freestone Creek	37°42'26" S 147°8'30" E	24/3/05
P. sp (bri4)	A. Messina 17 & N.G. Walsh	Culloden – Freestone Creek	37°42'2" S 147°8'46" E	24/3/0S
P. sp (briS)	A. Messina 19 & N.G. Walsh	Culloden – Freestone Creek	37°42'43" S 147°8'27" E	24/3/05
P. prunifolio (pru1)	A. Messina S & N.G. Walsh	Briagolong – Freestone Creek	37°49'45" S 147°4'9" E	24/3/05
P. prunifolio (pru2)	A. Messina 20 & N.G. Walsh	Culloden – Freestone Creek	37°42'43" S 147°8'27" E	24/3/0S
P. prunifolio (pru3)	A. Messina 21	Warrandyte – Jumping Creek	37°44'20" S 145°14'39" E	7/4/05
P. prunifolia (pru4)	A. Messina 22	Warrandyte – Jumping Creek	37°43'56" S 14S°14'24" E	7/4/0S
P. prunifolio (pru5)	A. Messina 2S	Brisbane Ranges – Anakie Gorge	37°S1'42" S 144°16'14" E	12/S/0S
P. prunifolia (pru6)	A. Messina 26	Brisbane Ranges – Shaft Track	37°S0'S1" S 144°15'26" E	12/5/05
P. prunifolio (pru7)	A. Messina 27 & C. Nield	Mallacoota – Inlet National Park	37°30'36" S 149°41'35" E	3/6/05
P. prunifolio (pru8)	A. Messina 3S, P. Green & C. Nield	Lake Buffalo	36°42'44" S 146°40'10" E	1S/7/05

a2647159

Notes and new taxa in *Lobelia* sect. *Holopogon* (Campanulaceae: Lobelioideae)

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Abstract

Descriptions and notes on distribution, habitat and conservation status are provided for three new species of *Lobelia* sect. *Holopogon* Benth., (*L. archeri* N.G.Walsh, *L. fissiflora* N.G.Walsh and *L. simulans* N.G.Walsh), and three new subspecies in existing species of the section (*L. heterophylla* Labill. subspp. *centralis* N.G.Walsh and *pilbarensis* N.G.Walsh, and *L. tenuior* R.Br. subsp. *dictyosperma* N.G.Walsh). The new taxa are from Western Australia and central Australia. The eastern states *Lobelia browniana* Schult. is recognised here at specific rank in contrast to recent Australian treatments. A key to the 19 members of *Lobelia* section *Holopogon* is provided.

Keywords: annual, post-fire species, stem-succulents

Muelleria 28(2): 146-162 (2010)

Introduction

In preparation of a full revision of *Lobelia* and related genera in Australia, a number of new taxa have come to light. A molecular phylogenetic study is in progress and in order to have names available for that work, the following account provides names for new taxa in section *Holopogon* Benth. (Bentham 1868), which includes mostly erect, few-leaved annual species, the best known and most widespread of which is probably *Lobelia gibbosa* Labill. A revised infrageneric classification of *Lobelia* circumscribes *Holopogon* as an entirely Australian section (Lammers 2010, in press) *contra* Wimmer (1956) who included in the section species from South and Central America, Mexico, southern Asia and Africa. The Australian members of section *Holopogon* have fascinating attributes that are unusual in *Lobelia*: some are first-year, post-fire species; some have minute seeds and mycorrhizal associations (Warcup 1988); some are stem-succulents with root systems that are dead at the onset of flowering (and continue to grow after being collected).

Two nomenclatural changes affecting the Australian species of *Lobelia* sect. *Holopogon* have recently been made. *Lobelia andrewsii* Lammers has replaced *L. gracilis* Andrews because it is a later homonym of *L. gracilis* Salisb. (Lammers 2001). *Lobelia winifrediae* Diels (honouring Miss Winifred Lynette George) has been corrected from the original publication as '*winfridae*' (Lammers 2007).

Taxonomy

1. *Lobelia archeri* N.G.Walsh *sp. nov.*

L. gibbosae *affinis sed planta plerumque minore e floribus minoribus (corolla ad 6.5 mm longa, tubo staminis ad 1.5 mm longo) differt.*

Type: Western Australia. 1 km S of Mt Merivale, 2.i.2006, *W.R. Archer 201061*m (holotype: MEL2331006; isotype: CANB!, PERTH!)

Erect *annual*, 15–45 cm high, arising from a short taproot. *Plants* simple,

MEL 2331006
HOLOTYPE
NATIONAL HERBARIUM OF VICTORIA (MEL)
Lobelia archeri N.G.Sakh. MS.
Determinavit N.G.Sakh. 25.i.2007
MELISR
Collection 201061 Lobelia archeri (3 sheets) Collected 2 January 2006
Approximately 50 plants with light blue flowers and a yellow throat, growing in deep sand, on a stabalised acid sand mound, along slashed tracks and in open spaces between Banksia speciosa and heath.
Location: 1 km South of Mt Merivale. 33° 49' 33" S. 122° 06' 08" E.
DUPL CANB PERTH.
NATIONAL HERBARIUM OF VICTORIA (MEL), AUSTRALIA

Figure 1: Holotype of *Lobelia archeri*.

rarely 1–few-branched below the inflorescence. *Stems* glabrous, terete, continuing growth after being uprooted. *Leaves* cauline, often withered at anthesis, sessile, linear, sometimes the very basal leaves obovate, 3–12 mm long, 0.2–0.8(–1.2) mm wide, entire, glabrous, sometimes purple-tinted, concolorous, veins indistinct. *Inflorescence* racemose, 3–7-flowered, flowers secund; pedicels ascending, 2–6 mm long, elongating to c. 8 mm in fruit, arising adjacent to a leaf-like bract 1.5–2.5 mm long on rachis with a similar bracteole inserted at the base of the pedicel. *Hypanthium* glabrous, narrowly obovoid, slightly asymmetrical, but hardly gibbous, 3–5 mm long, 2–3 mm wide. *Calyx-lobes* erect, narrowly triangular to subulate 1.1–2.5 mm long. *Corolla* 4–6.5 mm long, pale blue, the 3 ventral lobes with a darker zone near the base, distal to a yellow-green zone near the throat; tubular part of corolla 2–3.5 mm long, slit dorsally to the hypanthium, externally glabrous, internally sparsely pilose; upper 2 lobes recurved, entire, 1.4–1.8 mm long, 0.5–0.8 mm wide, glabrous or shortly papillose; lower 3 lobes spreading, central lobe elliptic to oblanceolate, 2.5–3 mm long, 1.3–1.5 mm wide, acute or subacute, lateral lobes of similar general shape to the central lobe but slightly falcate, 1.5–2 mm long, 0.8–1.2 mm wide; *staminal filaments* 1.2–1.8 mm long, glabrous, distally connate for up to 0.2 mm, basally free or adnate to corolla for up to 1 mm, anther tube 1.2–1.5 mm long, glabrous except for minute, even hairs at orifice c. 0.1 mm long. *Capsule* obconical to truncate-obovoid, not gibbous but often slightly asymmetric, 5–8 mm long, 2.5–3.5 mm diam. *Seeds* ellipsoid in outline, trigonous, 0.4–0.5 mm long, 0.3 mm wide, not winged but the angles minutely raised; testa smooth, ±shining, mid-brown. Fig. 1.

Flowering period: Flowers and fruits December to January.

Specimens examined: **WESTERN AUSTRALIA.** Woodup Swamp/Mt Merivale district, *W.R. Archer 30128920 & 1912012* (MEL2123149, 2123148); 2 km SSE of Mt Merivale, *W.R. Archer 2412041* (IND, MEL2265042); 1 km S of Mt Merivale, *W.R. Archer 2412042* (MEL2265039).

Distribution: Known only from the Mt Merivale area, c. 20 km east of Esperance. IBRA region ESP (DEWHA 2009–).

Habitat: Occurs on dune slopes of tertiary acid sands in low heathland dominated by Myrtaceae and Cyperaceae.

Etymology: The epithet commemorates William Archer of Esperance, Western Australia, who discovered the species and who has, to date, furnished all herbarium material of it.

Conservation status: This species is regarded as Critically Endangered (CR) *sensu* IUCN (2001).

Notes: Related to *Lobelia gibbosa* in general floral, fruit and seed morphology, but distinctly smaller in all floral parts and in the barely asymmetrical ovary and capsule. This is the smallest-flowered member of the Section *Holopogon*.

2. *Lobelia fissiflora* N.G.Walsh *sp. nov.*

L. rarifoliae *affinis lobis ventralibus corollae latioribus et lobis dorsalibus liberis e basi, filamentis ad corollam vix adnatis differt.*

Type: Western Australia. Kalbarri National Park, Z Bend, 8.ix.1990, *D.E. Albrecht 4311 & B.A. Fuhrer* (holotype: MEL2022811: isotype: NT!)

Erect *annual*, 7–40 cm high, arising from a short taproot. *Plants* simple or several-branched from midway or above, rarely from near the base. *Stems* glabrous, terete or with slight ridges decurrent from leaf bases, often reddish toward the base. Plant soon withering after being uprooted. *Leaves* cauline, sparse, mostly ±evenly spaced along stem, sessile, narrow-linear to lanceolate, 5–18 mm long, 0.5–2.2 mm wide, entire, glabrous, sometimes purple-tinted, concolorous, veins indistinct. *Inflorescence* cymose, sometimes a single flower, mostly up to 8-flowered; pedicels ±erect, 10–60 mm long, elongating only slightly in fruit, emerging from the axil of a leaf-like bract, with a reduced leaf-like bract to c. 5 mm long, attached around midway along pedicel. *Hypanthium* glabrous, obovoid, dorsally gibbous, 1.5–3.5 mm long, 2–4 mm wide. *Calyx-lobes* erect, narrowly triangular to subulate 2.5–3.5 mm long. *Corolla* 11–21 mm long, blue, mauve or purple, the 3 ventral lobes with a white or yellow patch toward the throat, distal to a small greenish patch; tubular part of corolla 4–7 mm long, completely slit dorsally, externally glabrous, internally often with a patch of short erect hairs in the palate; upper 2 lobes strongly recurved, entire, 2.5–4 mm long, 0.7–1.8 mm wide, glabrous or shortly ciliate on margins and/or tip; lower 3 lobes spreading, central lobe obovate 8–15 mm long, 6–11 mm wide, obtuse, sometimes shortly apiculate,

National Herbarium of Victoria (MEL)
HOLOTYPE
Lobelia fissiflora N.G.Walsh
MELISR
Determinavit N.G.Walsh 10.i.2010
NATIONAL HERBARIUM OF VICTORIA (MEL)
Lobelia sp. aff. rarifolia
Determinavit N.G.Walsh 25.i.2007
MELISR
NATIONAL HERBARIUM OF VICTORIA (MEL)
MELBOURNE, AUSTRALIA
MEL 2022811
307 CAMPANULACEAE
Lobelia rariflora F.Wimmer
Coll.: D.E. Albrecht 4311 Date: 8 Sep 1990
Addit. Coll.: B.A. Fuhrer
AUSTRALIA :WESTERN AUSTRALIA
Locality: Irwin Botanical District, Kalbarri National Park
Z-bend, cliffs above the Murchison River.
Lat.: 27°39'S Long.: 114°28'E
Notes: Growing in shrubland on pale brown sandy soil with
scattered surface sandstone rocks.
Annual herb with few leaves. Leaves green, Corolla light
sky blue, creamish yellow towards the centre; brownish
veins on the underside.
Fairly common. Ass. spp. include Eriostemon, Lobelia,
Cephalepterum, Casuarina sp., Eedelcolea monostachya,
Drackea.
DEA
4311
NATIONAL HERBARIUM OF
VICTORIA (MEL), AUSTRALIA

Figure 2: Holotype *of Lobelio fissifloro.*

lateral lobes obovate, asymmetric to slightly falcate, 7–11 mm long, 5–11 mm wide; *staminal filaments* 2.8–3.5 mm long, glabrous, distally connate for 1.2–1.5 mm, the non-dorsal filaments basally adnate to corolla for up to 0.8 mm; anther tube 1.2–2 mm long, glabrous except for minute, even hairs at orifice c. 0.2 mm long. *Capsule* obovoid, distinctly gibbous, 4.5–6 mm long, 3–4.5 mm wide dorsiventrally. *Seeds* ellipsoid in outline, trigonous to triquetrous, 0.25–0.3 mm long, c. 0.2 mm wide, not winged; testa smooth, ±shining, pale to mid-brown. Fig. 2.

Flowering period: Flowers and fruits September to November.

Specimens examined: **WESTERN AUSTRALIA.** Waddouring, Oct. 1915, *W.B. Alexander s.n.*, (PERTH); 300 mile post on Mullewa-Morawa Rd, *A.C. Burns 77*, (PERTH); Hartfield Rd, Forrestfield, *R.J. Cronfield 863* (PERTH); 23 km SSE of Sunday Bore, Perrinvale Stn, *R.J. Cronfield 7126*, (PERTH); Great Northern Hwy, 63.4 km NE of Wubin, *J.D'Alonzo 479*, (PERTH); 210.5 mile peg, Paynes Find Rd, *H. Demarz 5208* (KPBG, PERTH); 32.6 km N of Cleary on road to Paynes Find, *J.W. Green 5223*, (PERTH); 5 km S of Paynes Find, Great Northern Hwy, *M. Gustaffson & K. Bremer 106*, (PERTH, UPS); *M. Koch 1220* (PERTH); 3 km NE of Comet Vale townsite, *A.V. Milewski 91*, (PERTH); 2.5 km NE of Comet Vale townsite, *A.V. Milewski 406*, (PERTH); 28 km NE of Bungalbin Hill, *K. Newbey 9088*, (PERTH); Junction of Scottsmans Rd with north-east [road] out of Beacon, *B.H. Smith 786* (MEL1555062).

Distribution: Known from an area bounded in the south by Wubin and Comet Vale (c. 200 and 450 km inland respectively) to as far north as Kalbarri National Park within c. 50 km from the coast and Paynes Find (c. 300 km inland). IBRA Regions AW, GS, K, Y (DEWHA 2009–).

Habitat: Collectors' notes includes descriptions of habitat such as: '*Acacia* scrub, flat, sand with limestone', 'shrubland on skeletal soil with scattered surface rocks, associated spp. include *Eriostemon*, *Cephalipterum*, *Casuarina*, *Ecdeiocolea monostachya*', 'woodland, clayey sand over laterite', 'open scrub, clayey sand', *Eucalyptus leptopoda* over *Amphipogon caricinus* on reddish gravelly sand', '*Eucalyptus* spp., *Acacia coolgardiensis* – *Triodia scariosa* on deep sand'; 'granite silt – *Acacia*, *Grevillea*'.

Etymology: The epithet, from the latin *fissus* = cleft, and *flora* = flower, refers to the completely dorsally split corolla, particularly in relation to the similar *Lobelia rariflora* (see above).

Conservation status: The species is known from only 13 herbarium collections, and only six of these since 1980. Several unsuccessful searches have been made at the type locality at supposed appropriate dates in seasons of low and normal rainfall, suggesting that the species is very short-lived, limited to a very small population and/or responsive to particular weather patterns or fire regimes. It is conserved within Kalbarri National Park, but most, if not all, other collections are from roadsides or private property.

Considering the known range, the fragmentary nature of its distribution, and lack of recent collections, *Lobelia fissiflora* is considered to be probably either Vulnerable (VU) or Endangered (EN) applying the Red List criteria *sensu* IUCN (2001).

Notes: Apparently most closely related to *Lobelia rarifolia* E. Wimm. from which it differs by the much broader ventral perianth lobes, the completely dorsally cleft corolla 'tube' and the staminal filaments which are not or barely adnate to the corolla at their bases.

As far as is known, the species occurs north of latitude 30°S whereas *L. rarifolia* is known from only south of this line.

3. *Lobelia heterophylla* Labill., *Nov. Holl. Pl.* 1:52, t. 74 (1805)

Type: Van Leeuwin-Land. *Labillardière*. lecto (here chosen): FI!; isolecto: B – fiche seen at MEL), BM!, G!

Erect or somewhat sprawling *annual*, 5–40(–100) cm high, arising from a short to long taproot. *Plants* simple or branched from the base or above. *Stems* glabrous to hispid or pilose, usually somewhat to strongly angled, often glaucous, usually rather succulent and remaining so for considerable periods after being uprooted. *Leaves* basal and cauline, sometimes withered at anthesis, sessile or pseudopetiolate, linear to ovate or obovate, 10–70 mm long, 1–30 mm wide, entire or variously toothed to deeply pinnatifid with up to 6 teeth or narrow lobes on each side, glabrous to sparsely hispid, acute or obtuse at apex, concolorous, lateral veins usually apparent on lobed leaves. Inflorescence simple or several-branched of single or multiple cymes, superficially appearing racemose, flowers usually secund, pedicels arising more or less opposite a leaf-like bract on rachis, straight, arcuate or gently sinuate and upturned in distal part, 5–20(–35) mm long (elongating

to c. 45 mm in fruit), a bracteole 2–20 mm long present near halfway along pedicel. *Hypanthium* glabrous or sparsely (rarely densely) shortly hispid, truncate-obovoid to ellipsoid, 3–7 mm long, 2–5 mm wide. *Calyx-lobes* erect, narrowly triangular or ±linear, 3–7 mm long. *Corolla* 13–20(–25) mm long, sky-blue through lilac and mauve to deep purple, yellow in throat (often yellowish externally in bud); tubular part of corolla 8–15 mm long, slit dorsally to, or very nearly to, the hypanthium, externally glabrous (rarely sparsely hairy), internally sparsely hairy; upper 2 lobes scalpelliform to weakly arcuate, entire, 3–5 mm long, 1.5–2 mm wide; lower 3 lobes spreading, central lobe oblanceolate to obovate, 4.5–10(–16) mm long, 2–10(–16) mm wide, subacute to obtuse, sometimes apiculate, lateral lobes broadly falcate, 4.5–13 mm long, 2–12 mm wide, subacute; *staminal filaments* 5–9 mm long, glabrous, distally connate for 1–4.5 mm, basally free or adnate to corolla for up to 1 mm, anther tube 2.5–4.5 mm long, glabrous except for minute, even hairs at orifice 0.2–0.4 mm long, rarely extending as 2 short bands on dorsal surface. *Capsule* obovoid, ellipsoid or nearly globose, 6–15 mm long, 4–10 mm diam. *Seeds* ±ellipsoid in outline, acutely trigonous 0.8–2 mm long, 0.7–1.5 mm wide, including a 0.1–0.5 mm wing arising from each of the 3 angles, very rarely the wing vestigial, or the seed biconvex and 2-winged; testa smooth, shining, mid-brown.

Three subspecies are recognised.

3a. *Lobelia heterophylla* subsp. *heterophylla*

Erect or ascending *herb*, 5–40(–60) cm high, glabrous to shortly hispid. *Leaves* entire, shallowly toothed or pinnatifid, 10–30(–40) mm long, 1–6 mm wide, with up to 4 teeth or narrow lobes along each margin, usually somewhat thick-textured and conspicuously glaucous. *Pedicels* 8–25 mm long (to 35 mm in fruit). Hypanthium 3–6 mm long, 2–5 mm wide. *Calyx-lobes* 3–7 mm long. *Corolla* 15–22(–25) mm long; tubular part of corolla 10–15 mm long; central lobe 6.5–9.5 mm long, 6–8.5(–11) mm wide, lateral lobes 6–9 mm long, 3–5 mm wide. Capsule 8–15 mm long, 5–9 mm diam. *Seeds* 0.8–1.2 mm long, 0.4–0.6 mm wide.

Flowering period: Flowers and fruits October to December.

Selected specimens examined (total >250): **WESTERN AUSTRALIA.** 26.5 km NNE Mt Heywood *W.R. Archer 14129113* (MEL2019294); Eastern side of Barker Inlet, *W.R. Archer 2021011* (MEL); King George 3rd Sound, 1802, *R. Brown s.n.* (BM, MEL);28 km S from Billabong, *H. Demarz 8607* (KPBG); East Mt Barren, *A.S. George 554* (PERTH); Near Lake Lefroy, c. 25 km SE Kalgoorlie, xi.1891, *R. Helms s.n.* (AD); 80 km E of Lake King, *G.J. Keighery 412* (KPBG); Cockleshell Gully, *L.S.J. Sweedman 6017* (PERTH); 4 miles [6.4 km] W of Zanthus, *R.D. Royce 5273* (PERTH); Geraldton-Mt Magnet Rd, 1.6 km E of Pindar, *N.G. Walsh 5438* (IND, MEL2104929, 2104930, PERTH); North Twin Peak Island, Recherche Archipelago, 20.xi.1950, *J.H. Willis s.n.* (MEL2261467).

Distribution: Endemic to Western Australia, occurring widely from near the Gascoyne River south to Esperance, east to Zanthus area, and up to c. 300 km inland e.g. near Kalgoorlie, but commoner nearer the coast. IBRA regions CAR, COO, ESP, GS, JF, MUL, MUR, SWA, WAR, YAL (DEWHA 2009–).

Habitat: Occurs through a wide range of habitats (e.g. *Eucalyptus* and *Acacia* woodlands with *Triodia*, heath, shrubland), on a range of substrates (e.g. sand, loam, granitic and lateritic gravels, limestone-derived soils).

Notes: The commonest of the subspecies. Even with the segregation of *Lobelia cleistogamoides* N.G.Walsh & Albr. (Walsh & Albrecht 2007) and the other two subspecies described below, this remains a very variable entity in degrees of hairiness and degree of division of the foliage, glaucescence, degree of branching etc. At the northern limit of its range there is some approach to subsp. *pilbarensis*, but the stouter overall aspect of plants of subsp. *heterophylla* and their typically pronounced glaucescence usually allows ready separation.

Conservation status: It is regarded as of Least Concern (LC) applying the criteria of the IUCN Red List Categories (IUCN 2001).

3b. *Lobelia heterophylla* subsp. *centralis* N.G.Walsh *subsp. nov.*

Ab alii subspecie lobo medio corollae angustiore, seminibus majoribus, foliis glabris integris vel vix dentatis et habitatione desertorum differt.

Type: Northern Territory. KataJuta-Docker R. Rd, 56 km WSW of KataJuta t/o, 28.ix.2001, *D.E. Albrecht 10008* (holotype: NT!; isotype: MEL2263334)

Lobelia heterophylla subsp. Central Australia (*A.S. George 8132*) *sensu* Western Australian Herbarium (2009).

Erect or ascending *herb*, 10–40 cm high, glabrous.

Leaves linear to narrowly elliptic, 10–60 mm long, 1–7 mm wide, entire, or occasionally with 1–3 teeth to c. 2 mm long along each margin, often glaucous. *Pedicels* 7–35 mm long (to 45 mm in fruit). *Hypanthium* 3.5–6 mm long, 2–3.5 mm wide. *Calyx-lobes* 3–5 mm long. *Corolla* 13–20 mm long); tubular part of corolla 8–12 mm long; central lobe 4.5–7 mm long, 2–4(–5) mm wide, lateral lobes 4.5–7 mm long, 1.5–2.5 mm wide. *Capsule* 6–13 mm long, 4–8 mm diam. *Seeds* 1.3–1.5 mm long, 0.5–0.7 mm wide (not including wing). Fig. 3.

Flowering period: Flowers and fruits September to November.

Selected specimens (total 38): **WESTERN AUSTRALIA**. 21 km E of Terhan Rockhole on Warburton Rd, *A.S. George 8132* (PERTH); Little Sandy Desert, 8.2 km NW of Cooma Well, *S. van Leeuwen 2861* (MEL, PERTH). **NORTHERN TERRITORY**. 45 km SSE Docker R settlement, *P.K. Latz 980* (NT); Muranji Rockhole, Mt Winter, *B.G. Thomson 1580* (NT); East Lake, Amadeus Basin, *P.K. Latz 5701* (NT); Between Mt Olga and Barrow Range, 1873/4, *W.E.P. Giles* (MEL2261133); 28 km NNW Kings Canyon, *G. Leach 1166* (DNA, NSW, NT); Near Mt Connor, 18.x.1960, *G. Chippendale s.n.* (DNA, NT); 62 km NE of Charlotte Waters, 13.x.1957, G. Chippendale s.n. (AD, NT); NW Simpson Desert *N.M. Henry 1001* (BRI, NT, PERTH);. **SOUTH AUSTRALIA**. Great Victoria Desert, Connie Sue Hwy, c. 40 km W of Vokes Hill Junction, *D.E. Symon 12496* (AD); Musgrave Ranges, Mt Harriet Rd, c. 35 km S of Musgrave Park Stn, *J.Z. Weber 130* (AD, AK, COLO, NCU); Simpsons Desert, via Purnia and Mokari 8ores 78.4 km in from W edge, *D.E. Symon 9466* (AD).

Distribution: Occurs principally in central Australia, from the Western Australian border near Docker River east to the western part of the Simpson Desert and south to near Oodnadatta. Isolated specimens from the Little Sandy Desert and Terhan Rockhole in central Western Australia suggests that it is likely to occur in other areas between there and the Northern Territory border. IBRA regions CR, FIN, GD, GSD, GVD, MAC, SSD (DEWHA 2009–).

Habitat: Commonly associated with *Triodia* hummock grasslands and associated *Allocasuarina decaisneana* and *Acacia* spp. woodlands in sand dune country. Some collectors' notes refer to sites having been burnt and it is likely that germination is enhanced by recent fires.

Etymology: The epithet, from the Latin, refers to the distribution of this subspecies, which is principally central Australia.

Conservation status: Despite only 38 known collections, the occurrence of this subspecies in the largely unmodified and scantily collected Central Australian region suggests it is not at risk and is more widespread than current information indicates.

Notes: Likely to be locally abundant, but perhaps not germinating annually and possibly dependent on suitable conditions (e.g. fire, rainfall). It is distinguished from the other two subspecies by the wholly and consistently glabrous vegetative parts, the entire or nearly entire leaves, and the generally smaller flowers that have a distinctly narrower mid-lobe. The seeds are slightly larger than those of the other two subspecies (although this is based on a limited number of fruiting specimens).

3c. *Lobelia heterophylla* subsp. *pilbarensis* N.G.Walsh *subsp. nov.*

Ab alii subspecie foliis latioribus, membraneis, capsulis globosis vel subglobosis et habitatione plerumque in locis saxosis ferratis differt.

Type: Western Australia. Pilbara, Mt Nameless, c. 1 km S from summit, 22.ix.2006, *N.G. Walsh 6482, D. Halford & D. Mallinson* (holotype: MEL2296073; isotype: IND!, K!, PERTH!)

Lobelia heterophylla subsp. Pilbara (*R. Meissner & Y. Caruso 1*) *sensu* FloraBase (2009).

Decumbent, sprawling, or ascending to erect *herb*, 10–100 cm high, glabrous or stems, hypanthia and leaves sometimes invested with short fine erect hairs. *Leaves* oblong, elliptic, lanceolate, oblanceolate, ovate or obovate, c. 14–70 mm long, 3–30 mm wide, entire, irregularly toothed or shallowly lacerate with up to 6 teeth or lobes to c. 8 mm long along each margin, rather thin-textured and not conspicuously glaucous. *Pedicels* 5–15 mm long (to 40 mm in fruit). *Hypanthium* 3–7 mm long, 3–5 mm wide. *Calyx-lobes* 5.5–9 mm long. *Corolla* 16–22 mm long; tubular part of corolla 8–11 mm long; central lobe 8–16 mm long, 6–16 mm wide, lateral lobes 7–13 mm long, 7–12 mm wide. *Capsule* 8–10 mm long, 7–20 mm diam. Seeds 1–1.2 mm long, c. 0.5 mm wide (not including wing). Fig. 4.

Flowering period: Flowers and fruits August to November.

Selected specimens examined (total 26): **WESTERN AUSTRALIA**. Ca 27 km N Brockman Stn homestead, *W.R. Archer 309941* (MEL); 23 miles W of Wyloo, *H. Demarz 2475* (KPBG); Diamond Drillers Hill, Wittenoom, *Lullfitz 2743* (KPPG);

c. 5 km NE of Beringarra – Cue Rd, Jack Hills area, *R. Meissner & Y. Caruso 1*, (PERTH 7201354); 35.4 km S of Yalgoo, *L.S.J. Sweedman 2347* (KPBG); Kennedy Range, Gascoyne River area, ix.1948, *C. Teichert s.n.* (MEL); Hamersley Range NP, S side of Murandoo Ridge, *M.E. Trudgen 2255* (PERTH); 33.5 km from North West Coastal Highway on main access road to Glen Florrie Homestead, *S. van Leeuwen 5093* (AD, MEL, PERTH); Mt Phillips, Pilbara, Mt Brockman Range, *N.G. Walsh 6534* (MEL, PERTH); Augustus, *J.Z. Weber 4836*, (AD).

Distribution: Endemic to Western Australia, occurring from the Pilbara at least as far north as Tom Price, and south to the upper Murchison River catchment. A depauperate collection from near Yalgoo (*Sweedman 2347*) appears to be this subspecies and if so, represents a southern outlying population. IBRA regions GAS, MUR, PIL, ?YAL (DEWHA 2009–).

Habitat: Found mainly on and near cliff-lines of iron-rich sedimentary parent material, occurring with a diverse range of saxicolous specialists (e.g. *Astrotricha hamptonii, Corymbia ferriticolia, Eucalyptus gamophylla, Pomax rupestris, Rhodanthe margarethae*). Recorded, to a lesser extent, from flatter gibber country, and also from a granite outcrop.

Etymology: The epithet refers to the core distributional area of this subspecies in the Pilbara region of Western Australia.

Conservation status: Given the restriction or near-restriction of this subspecies to ironstone formations of the Pilbara, a geology that is being extensively mined for iron ore, it is considered to be Vulnerable (VU) applying the Red List criteria *sensu* IUCN (2001).

Notes: Locally common. Distinguished from the other subspecies by its less erect, often somewhat sprawling habit, its broader and thinner-textured, non-glaucous leaves, corollas with the mid-lobe usually relatively wider, and ovaries that enlarge after pollination to become nearly round in profile (at least in herbarium material). See also note under subsp. *heterophylla*.

4. *Lobelia simulans* N.G.Walsh *sp. nov.*

Lobelia winifrediae *et* L. rhytidospermae *affinis, a primo petalis dorsalis sine lobis falcatis auxiliaribus et a secundo seminibus largioribus et ab ambobus fissura dorsali corollae profundiore differt.*

Type: Western Australia. c. 30 km S of Mt Augustus, c. 325 km ENE of Carnarvon, 9.viii.1970, *A.M. Ashby 3397* (holotype: PERTH!; iso: AD!, F, G!, MEL!, NSW, TAI.)

Erect or ascending, *annual*, c. 6–30 cm high, arising from a short taproot. *Plants* unbranched or branched, usually from or near the base, but with little if any second-order branching. *Stems* glabrous (rarely minutely scabrous-papillate), angular to ±terete, subsucculent, often retaining moisture for several days after being uprooted. Leaves few, both basal (in a weak rosette) and cauline, but at least the basal leaves usually withered before flowering. *Leaves* oblanceolate, obovate or spathulate, 5–25(–40) mm long, 1–3(–6) mm wide, entire or with up to 3 short teeth or lobes on each side, glabrous or minutely scabrous-papillate, obtuse to acute at apex, concolorous, venation indistinct. *Inflorescence* an elongating monochasial cyme, sometimes appearing racemose and 1-sided, occasionally reduced to a single flower; pedicels 10–40 mm long (not differentiated in 1-flowered plants), usually with a simple linear bracteole 3–12 mm long attached c. 1/3–1/2 from the base of the pedicel. *Hypanthium* glabrous or minutely scabrous-papillate, obconical to obovoid, 6–9 mm long, 2.5–4 mm wide. *Calyx-lobes* erect, narrowly triangular, 5.5–8 mm long. *Corolla* 15–30 mm long, blue to mauve, yellow in throat, extending for a short distance on the central or all 3 ventral lobes; tubular part of corolla 7–12 mm long, slit dorsally to within 1(–2) mm of the hypanthium, glabrous; upper 2 lobes reflexed, arcuate, 6–11 mm long, ±entire, initially clasped over the anther tube via their fringed margins; lower 3 lobes spreading, central lobe broadly obovate or broadly spathulate, 9–18 mm long, 7–18 mm wide, obtuse or truncate, often shortly apiculate, lateral lobes similarly shaped to the central lobe but recurved-asymmetric, 7–12 mm long, 6–13 mm wide, the midrib arcuate and strongly eccentric; *staminal filaments* 4–8 mm long, glabrous, free from corolla, distally connate for up to 3 mm below anther tube, anther tube 2.5–4 mm long, glabrous except for minute, even hairs at orifice c. 0.5 mm long and longer, weakly tufted hairs at point of attachment to filaments. *Capsule* obconical or obovoid, 7–13 mm long, 3–5 mm diam. *Seeds* broadly ellipsoid, somewhat straight-sided, dark red-brown, (0.6–)0.7–1 mm long, 0.5–0.7 mm wide, dorsally rounded with 5–8 lumpy transverse ridges, sometimes discontinuous and/or sometimes

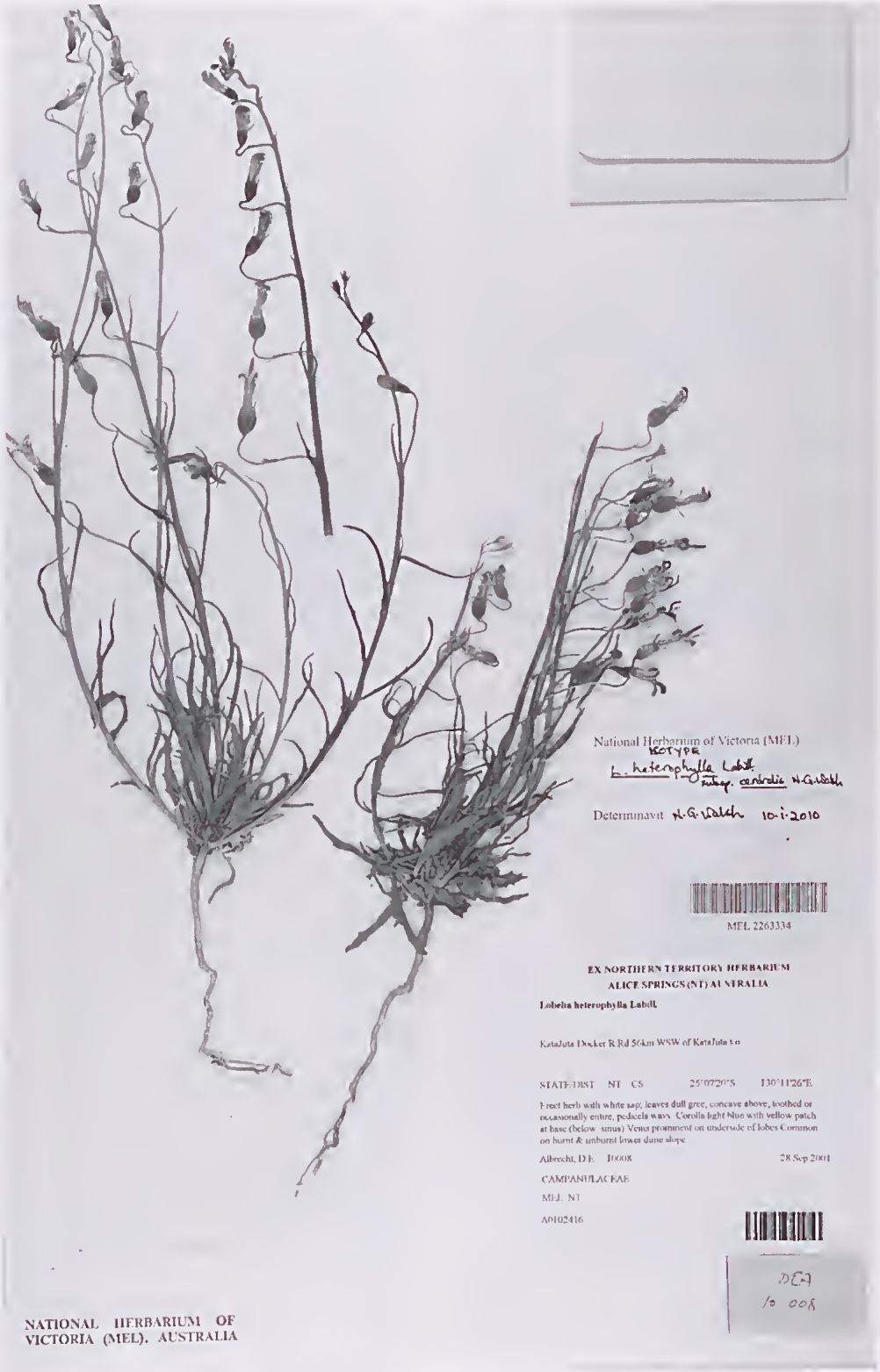
National Herbarium of Victoria (MEL)
ISOTYPE
L. heterophylla Labill. subsp. centralis N.G.Walsh
Determinavit N.G.Walsh 10-i-2010
MEL 2263334
EX NORTHERN TERRITORY HERBARIUM
ALICE SPRINGS (NT) AUSTRALIA
Lobelia heterophylla Labill.
KataJuta Docker R Rd 56km WSW of KataJuta t-o
STATE-DIST NT C5 25°07'20"S 130°11'26"E
Erect herb with white sap; leaves dull grey, concave above, toothed or occasionally entire, pedicels wavy. Corolla light blue with yellow patch at base (below sinus). Veins prominent on underside of lobes. Common on burnt & unburnt lower dune slope
Albrecht, D.E. 10008 28 Sep 2001
CAMPANULACEAE
MEL NT
A0102416
DEA
10 008
NATIONAL HERBARIUM OF
VICTORIA (MEL), AUSTRALIA

Figure 3: Isotype of *Lobelia heterophylla* subsp. *centralis*.

weakly anastomosing, ventrally with 2 shallow pits bordering the raised central rib; testa dull, smooth to minutely colliculate. Fig. 5.

Flowering period: Flowers and fruits August–November.

Specimens examined: **WESTERN AUSTRALIA.** 5E of of Coolcalalaya Station, *A.H. Burbidge 4511* (PERTH); 38 km 5 of Mt Magnet, *W. Greuter 22609* (PERTH); Gascoyne Junction – Pimbee Rd intersection, *G.J. Keighery & N. Gibson 1440* (PERTH); 30 km SE Mt Keith, Wanjarri Native Reserve, *G.J. Keighery 13016* (PERTH); 452 miles [732 km from Perth] near Billabong on Carnarvon Rd, *F. Lullfitz, 4269* (CANB, PERTH); 56 km from Meekatharra toward Wiluna, *A. Strid 20207* (PERTH); 11.8 km W Yamarna, *L.S.J. Sweedmon 2987* (KPBG); 45 km on Gascoyne Jn Rd East, *L.S.J. Sweedmon 51232* (KPBG); 35.7 km N of Mullewa Rd on Vermin Fence, *L.S.J. Sweedman 52437* (KPBG); Great Northern Hwy, 36–36.5 km S of Mt Magnet, *N.G. Walsh 6359* (CANB, MEL2295997, 2295998, PERTH).

Distribution: Endemic in Western Australia and occurring from near Gascoyne Junction south to near Paynes Find, and approaching the Great Victoria Desert near Yamarna at the south-east of its known range. IBRA regions CAR, GAS, MUR, YAL (DEWHA 2009–).

Habitat: Recorded mostly from sandy substrates supporting e.g. *Triodia* grassland, *Eucalyptus gongylocarpa*, *E. loxophleba*, *E. leptopoda–Acacia roycei* mallee associations, *Acacia ramulosa–A. aneura* shrublands. Also noted from sandstone breakaway country, and red loam soils over granite.

Etymology: The epithet, from the Latin *simulans* = imitating or resembling, refers to the resemblance of *L. simulans* to *L. winifrediae*.

Conservation status: Considering the restricted range and relative paucity of collections (a total of only 11 known from herbaria) of this species, *Lobelia simulans* is provisionally regarded as Vulnerable (VU) applying the criteria of the IUCN (2001), although targeted surveys may prove this to be an overly precautionary assessment.

Notes: *Lobelia simulans* appears to be most closely related to *L. rhytidosperma* and *L. winifrediae* on the basis of the strongly wrinkled, adaxially pitted seeds (which are unique in section *Holopogon*) and general habit. In its short, semi-succulent habit, it often strongly resembles *L. winifrediae* and has been named as such in most herbarium collections. It is readily distinguished from that species by the absence of the falcate or thumb-shaped lobe on each of the dorsal petals. *Lobelia rhytidosperma* is usually a much lankier plant, and lacks succulence, has a corolla that is less deeply cleft dorsally, seeds that are smaller and relatively narrower with a testa that is usually microscopically tuberculate (as well as the larger scale rugose texturing). Like *L. winifrediae*, plants of *L. simulans* retain moisture in a plant press for days or weeks, and often continue to grow therein whereas specimens of *L. rhytidosperma* wither soon after picking and dry conventionally in a press without further growth.

5. *Lobelia tenuior* R.Br., *Prodr.* 564 (1810).

Type: Western Australia. King George's Sound, Dec. 1801, *R. Brown* (R. Brown, Dec 1801), lecto (here chosen): BM!; isolecto: BM! CANB (photo seen)!

Erect *annual*, (10–)15–40 cm high, arising from a short taproot. *Plants* usually branched from the base or above, rarely simple. *Stems* glabrous to hispid or pilose, rarely densely so, terete to weakly angular, not succulent and withering soon after being uprooted. Lower *leaves* mainly cauline, obovate or spathulate in outline, becoming linear toward inflorescence, (4–)8–60 mm long, (1–)5–40 mm wide, (bi)pinnatisset, lobed or toothed, rarely entire (except near inflorescence) with up to 4 linear or narrowly obovate lobes or teeth on each side, glabrous, hispid or pilose, acute or obtuse at apex, concolorous or the lower surface paler, usually the midvein and lateral veins apparent. *Inflorescence* cymose or single-flowered, pedicels to c. 11 cm long, with a reduced, leaf-like bracteole at about (usually slightly above) midway. *Hypanthium* glabrous to pilose or hispid, rarely densely so, narrowly obconical to narrowly obovoid or nearly narrowly ellipsoid, (3–)4–7 mm long, 2–3 mm wide. *Calyx-lobes* erect, narrowly triangular, (3–)5–8 mm long. *Corolla* (8–)18–26 mm long, blue, mauve or purple, white and/or yellow in throat, extending for a short distance on the central or all 3 ventral lobes; tubular part of corolla (3–)6–10 mm long, slit dorsally to within 0.5 mm of the hypanthium, glabrous externally, sparsely pilose within; upper 2 lobes reflexed, oblanceolate-arcuate, 2.5–4 mm long, entire, margins (and often apical lamina) lightly fringed, not or weakly clasped over the anther tube; lower 3 lobes spreading, central lobe broadly obovate, broadly spathulate or obcordate, (6–)10–15 mm long,

National Herbarium of Victoria (MEL)
HOLOTYPE
MELISR
L. heterophylla Labill.
subsp. pilbarensis N.G.Walsh
Determinavit N.G.Walsh 10-i-2010
NATIONAL HERBARIUM OF VICTORIA (MEL)
MELBOURNE, AUSTRALIA
MEL 2296073
307 CAMPANULACEAE
Lobelia heterophylla Labill
Coll.: Walsh, N.G. 6482 Date: 22 Sep 2006
Addit. Coll.: Halford, D., Mallinson, D
AUSTRALIA . WESTERN AUSTRALIA
Region/District: Fortescue
Locality: Pilbara: Mt Nameless, c. 11km S from summit, c. 5 km SW from Tom Price township
Lat. 22°43'13"S Long.: 117°45'36"E
Alt.: 1100m
Notes: South-falling slope and cliffline. Shallow soil derived from red iron-rich parent material. Species at site include Astrotricha hamptonii, Acacia spondylophylla, Rhodanthe margarethae, Eucalyptus gamophylla, Pimelia forrestiana, Pomax rupestris, Goodenia stobbsiana, Callitris columellaris, Cryptandra monticola, Corymbia ferreticola etc.
Decumbent or weakly ascending herb to c. 25 cm high. Petals mainly purple with yellow bib in throat of corolla. Reasonably common.
Dupls: IND, K, PERTH
NATIONAL HERBARIUM OF VICTORIA (MEL), AUSTRALIA

Figure 4: Holotype of *Lobelia heterophylla* subsp. *pilbarensis*.

Figure 5: Isotype of *Lobelia simulans*.

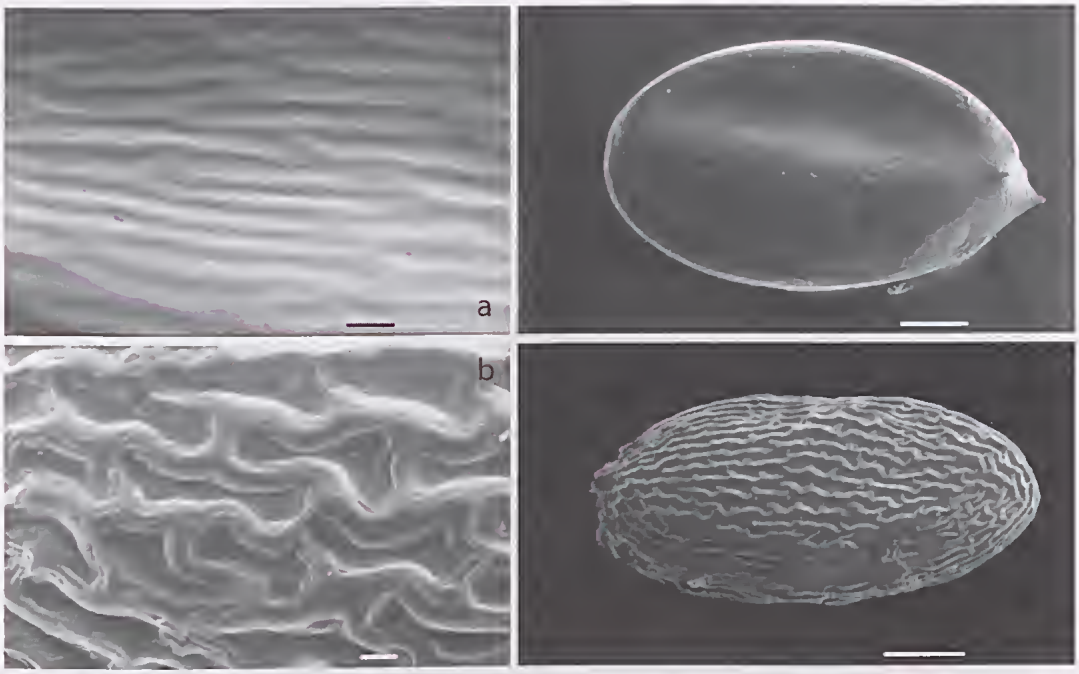

Figure 6: Scanning electron micrographs of *Lobelia tenuior* seed. 6a: subsp. *tenuior* (from *Orchard 4260* (AD)); 6b: subsp. *dictyosperma* (from the holotype). (scale bars of seed = 100 µm; scale bars of testa detail = 10 µm)

(8–)12–18 mm wide, obtuse, truncate or shallowly emarginate, sometimes shortly apiculate, lateral lobes similarly shaped to the central lobe but the midrib arcuate and strongly eccentric, 7–13 mm long, 5.5–9 mm wide; *staminal filaments* (3–)4.5–5.5 mm long, glabrous (occasionally weakly pilose near base), adnate to corolla for up to 2 mm, distally connate for up to 1 mm below anther tube; anther tube 1.8–2.5(–3) mm long, glabrous except for minute, even hairs at orifice (0.2–)0.3–0.5 mm long. *Capsule* narrowly obconical, obovoid or ellipsoid, 6–20 mm long, 3–5 mm diam. *Seeds* oblong to broadly ellipsoid, stramineous to dark brown, 0.4–0.7 mm long, 0.3–0.5 mm wide, virtually flat, quite smooth or finely elongate-reticulate.

Two subspecies are recognised.

5a. *Lobelia tenuior* subsp. *tenuior*

Plants to 40(–60) cm high, usually with vegetative parts sparsely to moderately hispid, hairs sometimes confined to lower leaves, rarely quite glabrous. *Hypanthium* 4–7 mm long; calyx lobes 5–8 mm long; corolla 18–26 mm long; *staminal filaments* 4.5–5.5 mm long, all but the dorsal one adnate to the corolla for 1–2 mm; anther tube 2–2.5(–3) mm long. *Capsule* narrowly obconical or almost cylindrical. *Seeds* broadly ellipsoid, 0.6–0.7 mm long, 0.4–0.5 mm wide, smooth, stramineous. Fig. 6a.

Flowering period: Flowers and fruits mostly October to January.

Selected specimens examined (total 62): **WESTERN AUSTRALIA.** Cape Naturaliste, *M.G. Corrick 9016* (MEL662368); Albany area, road to Correctional Centre, *J.C. Reid & N. duPreez 1100*, (MEL2097692); Wanneroo, *H. Demarz 8643* (KPBG); Fish Creek, 26 km ESE of Windy Harbour, *R.W. Hearn, ARA 5258*, (PERTH); Kings Park, *L. Lelle 5126*, (KPBG); Kelmscott (Perth suburb), 20.xi.1897, *A. Morrison s.n.* (BRI); Claremont, 18.xii.1897, *A. Morrison s.n.* (CANB); Welshpool area near Perth, 1946, *W.H. Nicholls, s.n.* (MEL); 23 km W of Gin Gin, *A.E. Orchard 4260* (AD, AK); William Bay National Park, *N.G. Walsh 5454* (IND, MEL2123054, 2123055, PERTH); City Beach, 7.5 miles W of Perth, 14.ix.1947, *J.H. Willis s.n.* (MEL2306957).

Distribution: Occurs mostly within c. 20 km from the coast from just north of Perth (Gin Gin area), south and east to Albany. IBRA regions ESP, GS, JF, SWA, WA (DEWHA 2009–).

Habitat: Occupies a variety of habitats, but mainly heathland and heathy woodland on sandy soils.

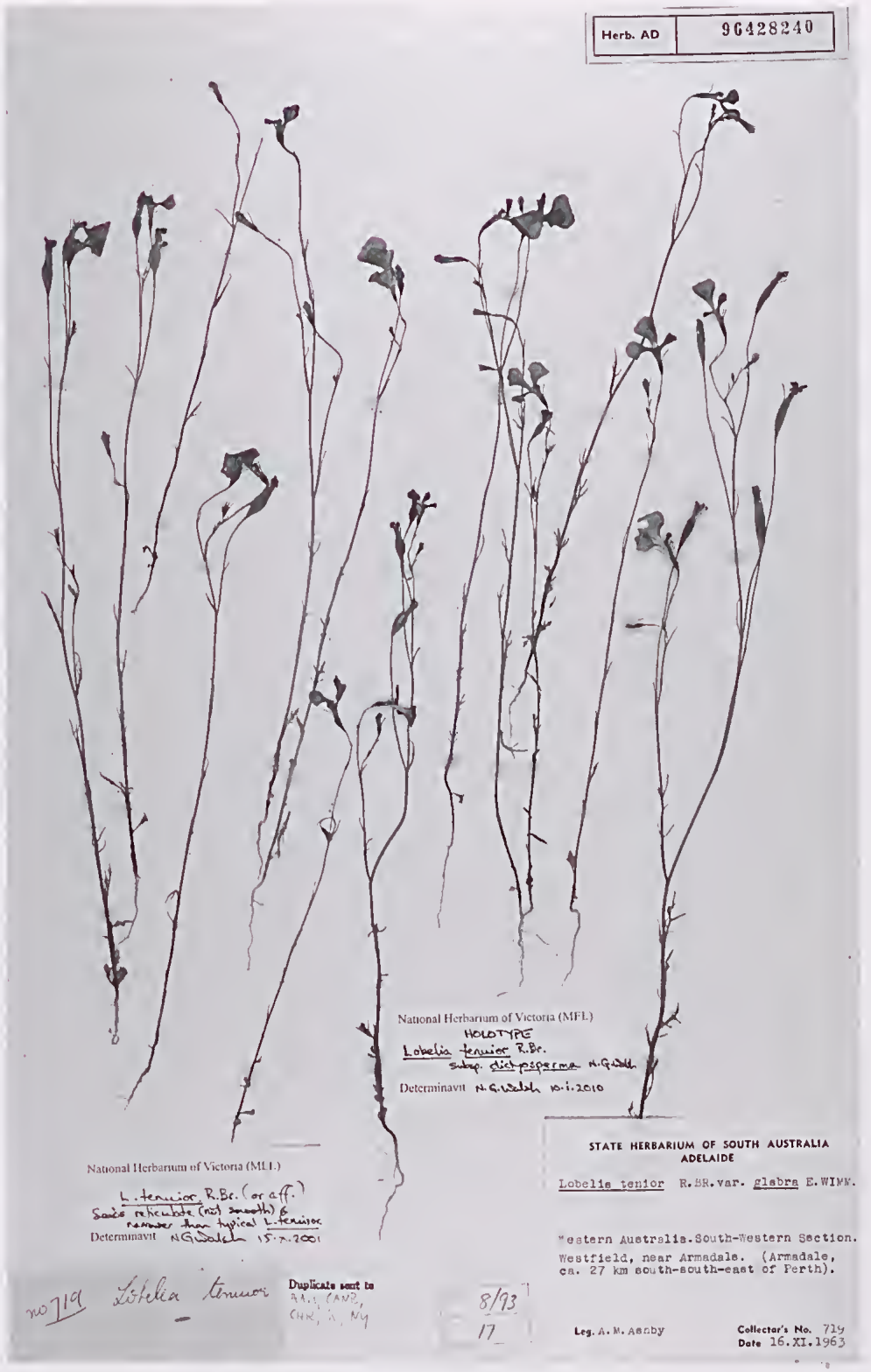

Figure 7: Holotype of *Lobelia tenuior* subsp. *dictyosperma*.

Collectors' notes include comments such as 'Eucalyptus gomphocephala woodland', 'white sand around dam', 'over limestone', 'interdune peat swamp', 'low coastal heathland, deep sand'.

Notes: *Lobelia tenuior* subsp. *tenuior* is not currently regarded to be at risk, and is well represented in several conservation reserves, but its restriction to the coastal fringe means that it may become at least locally rare through coastal development in much of its current area of occurrence.

5b. *Lobelia tenuior* subsp. *dictyosperma* N.G.Walsh *subsp. nov.*

A subspecie typica seminibus angustioribus elongato-reticulatis atrobrunneis differt.

Type: Western Australia. South-western section. Westfield near Armadale, 16.xi.1963, *A.M. Ashby 719*. holo: AD!; iso: AAU, CANB, CHR, K, NY.

Plants 10–25 cm high, vegetative parts wholly glabrous. *Hypanthium* 3–5 mm long; calyx lobes 3–6 mm long; corolla 8–17 mm long; *staminal filaments* 4.5–5.5 mm long, all but the dorsal one adnate to the corolla for up to 0.5 mm; anther tube 1.8–2.2 mm long. *Capsule* narrowly obovoid (distinctly broadest below apex). *Seeds* rather narrowly elliptic, 0.4–0.6 mm long, 0.3–0.4 mm wide, finely elongate-reticulate, patterned by series of fine anastomosing ridges, dark brown or dark reddish-brown. Figs. 6b, 7.

Flowering period: Flowers and fruits October–December.

Specimens examined: **WESTERN AUSTRALIA.** Wanneroo, *H. Demarz 3559* (PERTH) Bayswater, Lower Swan River, *A. Morrison 394* (K); Lower Swan River, *A. Morrison 385* (K); Bayswater to Perth, *A. Morrison 395* (K); Bayswater, Kelmscott, Canning River, *A. Morrison 20059* (K);

Distribution: Known only from the greater Perth area. IBRA regions SWA (DEWHA 2009–).

Habitat: Largely unknown. *Demarz 3559* notes 'new pine plantation, sand'.

Etymology: The epithet, from the Greek *dictyon* = a net and *sperma* = seed, refers to the reticulate pattern of the seed surface in contrast to the nearly smooth surface of the typical subspecies' seed.

Conservation status: The subspecies is known from only 5 herbarium collections, and only 2 of these since 1950. All collections are from within the greater Perth area, and most of its former habitat has very likely been lost to urban development. It is regarded as Critically Endangered (CR), but may conceivably be extinct (EX) according to IUCN Red List criteria (IUCN 2001).

Notes: As well as the reticulate, darker and narrower seed, this subspecies usually differs from subsp. *tenuior* in the floral parts being smaller, but there is some overlap in these dimensions. Specimens of subsp. *dictyosperma* seen to date are entirely glabrous vegetatively whereas there is *usually* some indumentum apparent on subsp. *tenuior* (but see comment about var. *glabra* below). The degree of adnation of the 4 lateral staminal filaments appears to be consistently smaller. Also, capsules of subsp. *dictyosperma* tend to be distinctly, if narrowly, obovoid or ellipsoid, whereas those of subsp. *tenuior* are more or less straight-sided, either cylindric or narrowly obconical.

Wimmer cited a specimen here referred to *Lobelia tenuior* subsp. *dictyosperma* (Morrison, Bayswater) under *L. tenuior* var. *glabra* E.Wimmer (syn *L. adscendens* de Vriese, *L. longepedunculata* de Vriese). This variety is not maintained as distinct in the present study, but the type, and all other specimens cited by Wimmer for var. *glabra* that we have seen [e.g. *Pritzel n. 12* (G), *Preiss 1425, 1433, 1445, 1452* (all G, MEL)] are all smooth-seeded, thus not subsp. *dictyosperma*. Like subsp. *dictyosperma*, occasional plants of the typical subspecies are entirely or virtually glabrous.

Although contrary to the commonly upheld position that subspecies be, at least largely, allopatric, subspecies status is given here. The entire known range of subsp. *dictyosperma* is contained within that of the typical subspecies. Although based primarily on seed characters only, the distinction between the two subspecies, when seen, is quite unmistakeable. A status higher than subspecies may be warranted, but, with only limited material available, no entirely discontinuous vegetative or floral characters could be found to further separate the two entities. Further searches in remnant native vegetation around Perth are encouraged so that a wider selection of material may provide sufficient information to be confident about the correct rank of this entity.

Key to members of *Labelio* section *Holopagan* in Australia

1 Inflorescences racemose, one-sided, unbranched or sometimes with up to c. 5 (rarely more) ± erect branches 2

1: Inflorescences cymose, paniculate or of solitary flowers 13

2 Leaves ovate to orbicular, truncate or cordate at base; vegetative stems prostrate or decumbent; Qld, NSW ..... ***L. trigonocaulis***

2: Leaves linear to elliptic, gradually tapered at base; vegetative stems erect 3

3 Corolla with mid-lobe of lower lip distinctly obovate to spathulate, length less than 3 (usually less than 2) times width, mostly wider than 3 mm 4

3: Corolla with mid-lobe of lower lip linear to elliptic (occasionaliy oblanceolate), length more than 3 times width, rarely (in *L. dentata*) wider than 3 mm wide 9

4 At least lower leaves ovate to elliptic, more or less reguiarly dentate; Qid, NSW ..... ***L. ondrewsii***

4: Leaves linear to obovate, entire, remoteiy or irreguiarly toothed or pinnatifid; WA, NT, SA 5

5 Corollas <9.5 mm long; WA, SA ..... ***L. cleistogomoides***

5: Corollas >9.5 mm long 6

6 5eeds ±plano-convex, with 3–6 conspicuous transverse grooves or ridges on the dorsal surface; lower 3 corolla lobes as wide as long or wider; WA ..... ***L. simulons***

6: 5eeds trigonous, usually winged, smooth; lower 3 corolla lobes generaliy longer than wide ..... 7 (***L. heterophyllo***)

7 Mid-lobe of lower lip of flower 3(–5) mm wide or less, obtuse to subacute, widest near middle; seed (including wing) 1.5 mm long or more; leaves glabrous, lanceolate to oblanceolate or linear, entire or shaliowly toothed, never pinnatifid; central Australia (WA, NT, SA) ..... ***L. heteraphylla*** subsp. ***centrolis***

7: Mid-lobe of lower lip of flower 6 mm wide or more, broadest near apex where often almost truncate except for apiculate mid point; seeds to 1.5 mm long; ieaves giabrous to hispid, often pinnatifid; within 500 km of WA coast 8

8 Leaves (except sometimes the very basal ones) deeply pinnatifid with linear lobes and rachis <3 mm wide, or entire and linear and less than 3 mm wide, often rather fleshy *in vivo*, soon drying and margins becoming strongly inrolled, entire leaf often tightly coiling; ovary obovoid to obconical post-anthesis; mostly south from Carnarvon area, WA ..... ***L. heterophyllo*** subsp. ***heterophyllo***

8: Leaves entire, shallowiy pinnatifid (with lobes broader than linear) to lacerate with rachis >3 mm wide, or if entire, lamina >3 mm (up to c. 15 mm) wide; leaves membranous, drying more or less flat; ovary globose post-anthesis; mostly north from Carnarvon, WA ..... ***L. heteraphylla*** subsp. ***pilborens***

9 5eeds strongly 3-angled, 0.45–0.7 mm long; SA, NSW, Vic., Tas. ..... ***L. simplicicoulis***

9: Seeds not strongly 3-angied, 0.1–0.25 mm iong 10

10 Lower leaves oblanceolate to obovate or spathulate, 2–12 mm or more wide, the widest leaves less than 5 times as long as wide; NSW, Vic. ..... ***L. dentato***

10: Lower leaves linear to narrowly oblanceoiate, at least 5 times as long as wide 11

11 Corolla 4–6.5 mm long; anther tube 1.2–1.5 mm long; known only from Esperance area, WA ..... ***L. archeri***

11: Corolla >8 mm long; anther tube >1.8 mm long; various states 12

12 Anther tube 2.5–4 mm long; corolla 10–20 mm long (very rarely as small as 2 mm and 8 mm respectively in WA oniy); central corolla lobe ±narrowiy elliptic, acute; leaves entire; ovary not strongly gibbous, widest near the apex; all states ..... ***L. gibboso***

12: Anther tube 1.8–2.3 mm long; corolla 8–14 mm long; central corolla lobe oblanceolate to oblong, usually obtuse, apiculate; leaves usually toothed, occasionaily entire; ovary strongly gibbous, widest near midpoint; SA, Qld, NSW, Vic., Tas. ..... ***L. browniono*** (see note below key)

13 Leaves linear to narrowly lanceolate, entire or minutely toothed 14

13: At least the basal leaves eiliptic to rhombic or obovate, variousiy incised 15

14 Corolla slit dorsaily to within 1.5–2.5 mm of caiyx; lateral lobes of lower iip of corolla distinctly falcate; WA ..... ***L. rorifolio***

14: Corolla slit dorsally to the calyx; lateral lobes of lower lip of corolla not or indistinctly falcate; WA ..... ***L. fissiflora***

15 Mid-lobe of lower lip of corolla narrowly elliptic to narrowly obovate; plants often many-branched; seeds smooth, <0.4 mm long; WA, SA, Vic., Tas. ..... ***L. rhombifolia***

15: Mid-lobe of lower lip of corolla broadly obovate, spathulate or obcuneate; plants unbranched or with few branches, rarely many-branched; seeds deeply wrinkled on at least one face, or, if smooth, >0.5 mm long **16**

16 Each of the upper, reflexed, pair of corolla lobes with a distinct falcate lobe longer than it is wide from the ventral margin; WA ..... ***L. winifrediae***

16: Upper pair of corolla lobes entire, or if ever somewhat lobed (rarely, in *L. rhytidosperma*), then the lobe neither falcate nor longer than wide **17**

17 Seeds smooth or finely reticulate; upper and lower surfaces similar; WA ..... **18** (***L. tenuiar***)

17: Seeds with 3–6 conspicuous transverse ridges or grooves on the dorsal surface; lower surface deeply pitted **19**

18 Seeds pale brown, smooth, about 3/4 as wide as long; plants usually hispid, at least on lowest leaves ..... ***L. tenuiar*** subsp. ***tenuiar***

18: Seeds dark brown, patterned by series of fine anastomosing ridges, about 1/2 as wide as long; plants glabrous on all vegetative parts ..... ***L. tenuiar*** subsp. ***dictyasperma***

19 Corolla slit dorsally to within 2.5–7 mm of calyx; plants usually >15 cm tall, not or hardly succulent, withering soon after uprooted; at least some plants in populations ±hispid on leaves, stems and hypanthium; WA ..... ***L. rhytidasperma***

19: Corolla slit to the calyx or to within 2 mm of it; plants usually <15 cm tall, ±succulent, remaining turgid and often continuing to grow for days after being uprooted; plants essentially glabrous, but leaves and hypanthium sometimes minutely scabrous-papillose; WA ..... ***L. simulans***

Although *Lobelia browniana* Schult. was originally described as a distinct species, it has been treated for the past century as a variety of the closely related *L. gibbosa*. However, there are distinctive morphological features that recommend retaining this taxon at specific rank.

Acknowledgements

We are grateful to the staff of Australian herbaria for the provision of loans, to ABLOs Peter Bostock, Juliet Wege, Annette Wilson and Tony Orchard for locating types and providing information of holdings of Australian *Lobelia* in European herbaria, and to staff at BM, F and G for their hospitality and access to historical collections in those institutions when visited by NGW in 2009. We are very grateful to people who have collected or who have arranged for the collection of specimens on our behalf, in particular, William Archer of Esperance and Juliet Wege (PERTH).

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Australian type material in the Economic Botany Collection, Royal Botanic Gardens, Kew

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Introduction

The purpose of this paper is to draw attention to some type collections housed in the Economic Botany Collection at the Royal Botanic Gardens, Kew. They were lodged in the Collection well over a century ago and, perhaps because the Collection is physically separate from the Herbarium, appear to have been overlooked by taxonomists in recent decades. Kew's Museum was opened to the public on 20 September 1847 (as recorded on the title page of the first Museum Entry Book), soon after the establishment of the Gardens themselves as a public institution in 1841. By 18SS the museum was known as the Museum of Economic Botany; it was to grow to occupy four buildings at Kew, including the Orangery. In the late 1980s the Museum was renamed the Economic Botany Collection, and its specimens were rehoused in a purpose-built research store in the Sir Joseph Banks Building, just west of the Herbarium. It holds plant and fungal specimens and materials of economic importance, or potentially so, from all parts of the world, as well as many artifacts made from natural materials. Among these are some 2800 specimens sent from Australia, in particular during the second half of the 19th century. Colonists and explorers were investigating the natural resources of the country for any products that might be of some economic or material benefit. Samples of those known or thought to be of some benefit (e.g. timbers, resins, fibres) were sent to Europe, some for promotional display at international exhibitions held in cities such as London and Paris (Desmond 1995) but also directly to Kew. An especially intriguing item is a travelling desk made by a convict from Australian timbers taken back to England by Ferdinand Bauer in 180S (George 2006).

The receipt of items was recorded in Museum Entry Books which survive intact from the opening of the Museum to the present day. Figure 1 shows page 219 from the Entry Book for the years 18SS to 1861, listing items from the North Australian Expedition (amusingly, giving Mueller's first name as 'Fred'). It includes the entries for receipt of *Adansonia* and *Casuarina*, discussed below. Sadly, some of the items sent no longer survive, e.g. samples of coal and other items sent by Surveyor-General J.S. Roe, Western Australia, received 9 November

Abstract

Fourteen collections representing type or possible type material of Australian plants, housed in the Economic Botany Collection at the Royal Botanic Gardens, Kew, are documented and illustrated. They appear to have been overlooked by taxonomists. One, *Hicksbeochio pinnotifolio* F.Muell., may be all that remains of the type material. The others are: *Adonsonio gregorii* F.Muell., *Cosuorino decaisneona* F.Muell., *Eucalyptus dichromophloio* F.Muell., *Eucolyptus megocarpo* F.Muell., *Eucalyptus ptychocorpo* F.Muell., *Helicio sayeriano* F.Muell., *Kentio belmoreano* C.Moore & F.Muell., *Kentio conterburyana* C.Moore & F.Muell., *Kentio mooreano* F.Muell., *Livistona alfredii* F.Muell., *Musa banksii* F.Muell., *Paederoto densifolio* F.Muell., *Pondonus forsteri* C.Moore & F.Muell.

Keywords: Museum of Economic Botany, Kew; Australia; type specimens; Ferdinand Mueller

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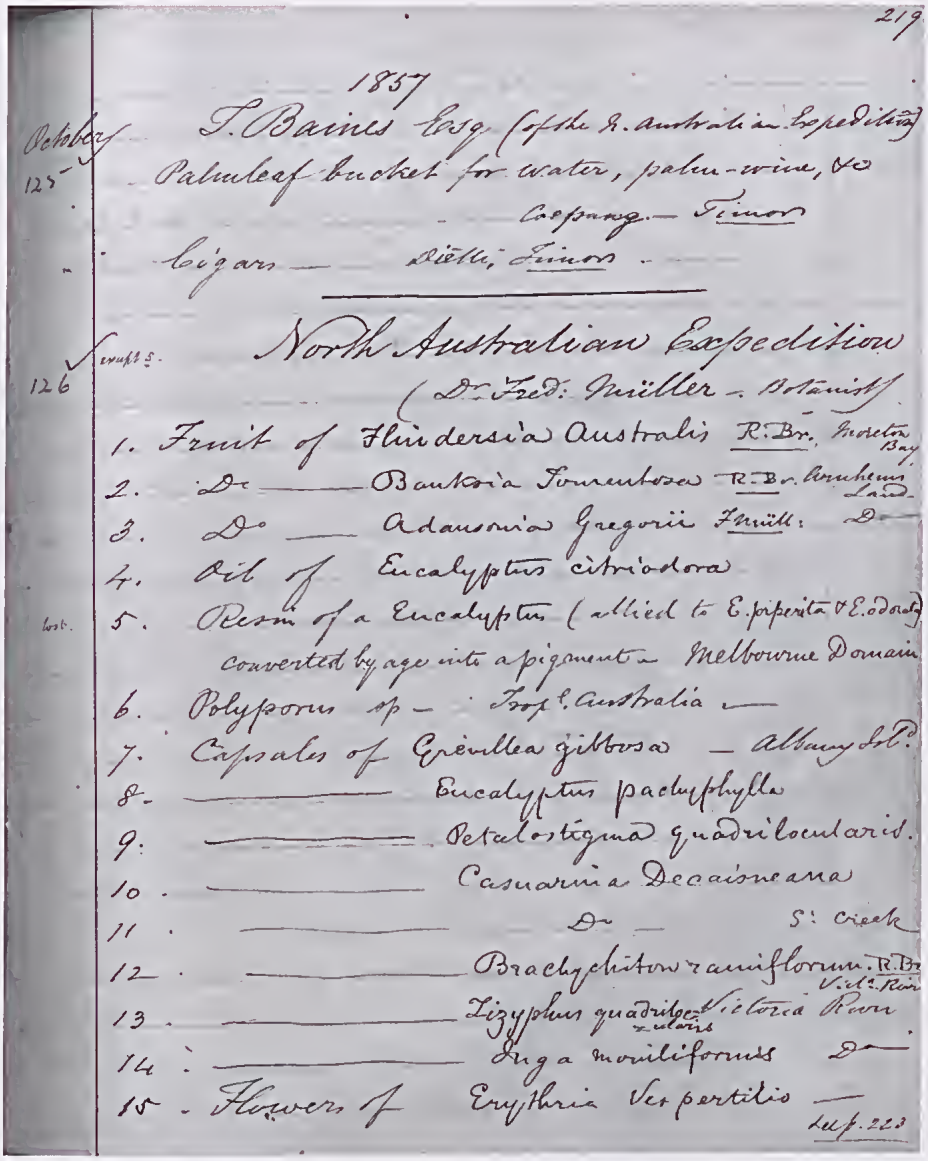
219
1857
October
T. Baines Esq. (of the N. Australian Expedition)
125
Palmleaf bucket for water, palm-wine, &c
Coepang — Timor
Cigars — Dilli, Timor
North Australian Expedition
126
(Dr. Fred: Mueller — Botanist)
1. Fruit of Flindersia Australis R. Br. Moreton Bay
2. Do — Bankia Tomentosa R. Br. Arnhems Land
3. Do — Adansonia Gregorii F. Müll: Do
4. Oil of Eucalyptus citriodora
5. Resin of a Eucalyptus (allied to E. piperita & E. odora) converted by age into a pigment — Melbourne Domain
6. Polyporus sp — Trop. Australia
7. Capsules of Grevillea gibbosa — Albany W.A.
8. — Eucalyptus pachyphylla
9. — Petalostigma quadriloculare
10. — Casuarina Decaisneana
11. — Do — S. Creek
12. — Brachychiton ramiflorum. R. Br. Vict. River
13. — Zizyphus quadrilocularis Victoria River
14. — Inga moniliformis Do
15. Flowers of Erythrina Vespertilio
Lep. 223

Figure 1: Page 219 of the Museum Entry Book 1855–1861. © Board of Trustees of the Royal Botanic Gardens, Kew.

1853, and 3 cones of *Araucaria bidwillii*, received from John Carne Bidwill himself on 11 January 1851.

A large number of items were sent to Kew by the Government Botanist of Victoria, Ferdinand Mueller, including specimens that he collected during the North Australian Exploring Expedition of 1855–56 led by Augustus Gregory. Mueller also received specimens from many collectors spread widely across Australia. There are references to various consignments in his correspondence, e.g. Home *et al.* (1998 p. 301). Some items are now of mainly historical interest, e.g. samples of cotton grown presumably as a trial at Mt Narryer Station, WA., in the 1890s. During my term as Australian Botanical Liaison Officer in 2004–05, I was particularly interested to find some Australian type material housed in the Museum and recorded the collections below, all donated or associated in some way with Ferdinand Mueller and his collectors. These were items that stood out as possible types from a scan of an electronic catalogue for the Collection

which is accessible only within Kew. I did not have time to examine all the Australian material – it would take many weeks to do this. It is likely that there is more material from type collections, but some may be in the form of products such as resin, fibre etc.

My conclusion that these are or may be type material is based on the data accompanying them, i.e. botanical name, locality, date (or date of receipt at Kew), collector (or Mueller as donor), and comparison with equivalent data in the protologue.

The species are listed in alphabetical order under their originally published names. The place of publication is cited, with the type citation (from the protologue), the location of herbarium sheets of type material, and comments on the collectors. References are cited for other information on types and collectors. Data documented for each sample are the Economic Botany Collection (EBC) catalogue number, the Museum Entry Book number, name of donor, date of receipt, transcript of any extant labels, and brief description of material. A photograph of each sample is included.

1. *Adansonia gregorii* F. Muell., *Hooker's J. Bot. Kew Gard. Misc.* 9: 14 (1857) (Bombacaceae)

Type citation: 'In planitiebus orariis et ripariis ad flumina Victoria et Fitzmaurice, ad promontorium Point Pearce alibique'.

A collection in MEL (MEL 229658), made by Mueller from the Victoria River was selected as lectotype by D. Baum (1995), with possible isotypes at BM and GH.

EBC Catalogue no. 65247; Entry Book no. 126.1857. From the North Australian Exploring Expedition which, led by Augustus Gregory with Ferdinand Mueller as botanical collector, explored northern Australia in 1855–56 (Gregory & Gregory 1884). Received at Kew 1857. Two fruit, one cut transversely, the other lengthwise, both with the seed mass extant (Fig. 2). The Collection also has a wood sample from the same expedition, EBC Catalogue no. 2445.

2. *Casuarina decaisneana* F. Muell., *Fragm.* 1: 61 (1858)

basionym for *Allocasuarina decaisneana* (F.Muell.) L.Johnson, *J. Adelaide Bot. Gard.* 6: 74 (1982) (Casuarinaceae)

Type citation: 'Rara in eremo arenoso Australiae centralis; e.c. juxta Mount Mueller'.

The type was collected by Mueller on the North Australian Exploring Expedition. Mount Mueller (19°52'S, 127°46'E) was named after him by Gregory on 2 March 1856 (Gregory & Gregory 1884). Nine days later, as the party was returning up Sturt Creek, Gregory mentioned the hill again and noted that 'we passed through a patch of casuarina forest, which was remarkable, as they are the only trees of this genus we had seen on the coast since landing at the Victoria'. This implies that they had not seen them on the outward trip, and it was probably on this day when Mueller made his collection. Wilson and Johnson (1989) stated that they had not found any type material at MEL, and that an isotype at K was vegetative only.

EBC Catalogue no. 42524; Entry Book no. 126.1857. Donated by F. Mueller. Received at Kew in 1857. Three fruit, one cut lengthways. Fig. 3.

3. *Eucalyptus dichromophloia* F. Muell., *J. Proc. Linn. Soc., Bot.* 3: 89 (1859)

basionym for *Corymbia dichromophloia* (F.Muell.) K.D.Hill & L.A.S.Johnson, *Telopea* 6: 295 (1995) (Myrtaceae)

Type citation: 'In locis minus fertilibus sterilibusve Australiae intratropicae passim, Anth. Apr., Mai'.

Mueller collected this species three times while on the North Australian Exploring Expedition. Blake (1953) chose the MEL collection of October 1855 from the Fitzmaurice Ranges as lectotype; there are duplicates in K and NSW.

EBC Catalogue no. 55185; no record in Entry Book. Received at Kew in 1857. Donated by F. Mueller. A single fruit, a twig and a leaf, but the box also contains four fruits of the south-western Australian *Eucalyptus pleurocarpa* Schauer, clearly an admixture. A typed label gives 'North Australia' and a comparison with the three Mueller collections of *E. dichromophloia* is required to determine if this material can be matched with one of them. Fig. 4.

4. *Eucalyptus megacarpa* F. Muell., *Fragm.* 2: 70 (1860) (Myrtaceae)

Type citation: 'ad sinum Wilson's Inlet ... juxta flumina Franklin River et Deep River'.

Figure 2: *Adansania gregarii* EBC65247 © Baard *af* Trustees *af* the Rayal Batanic Gardens, Kew.
Figure 3: *Casuarina decaisneana* EBC42524 © Baard *af* Trustees *af* the Rayal Batanic Gardens, Kew.
Figure 4: *Eucalyptus dichramaphlaia* EBC55185 © Baard *af* Trustees *af* the Rayal Batanic Gardens, Kew.
Figure 5: *Eucalyptus megacarpa* EBC55250 © Baard *af* Trustees *af* the Rayal Botanic Gardens, Kew.

Chippendale (1988) cited a collection by George Maxwell at Wilson Inlet in 1858 as the type (two syntype sheets at MEL, one at PERTH). Maxwell was a collector for Mueller (George 2009). Since there is no other collection of the species this early, the material at EBC is probably part of the same gathering. There is no matching herbarium sheet at K.

EBC Catalogue no. 55250; Entry Book no. 141.1861. Received at Kew in 1861. Donated by F.Mueller. A twig, three leaves and nine fruits. This has a label in Mueller's hand: 'for Sir Will Hooker Blue Gum Eucalyptus megacarpa ferd Mueller S.W.Australia'. This is one of several eucalypts called Blue Gum by early settlers in Western Australia. Fig. 5.

5. *Eucalyptus ptychocarpa* F. Muell., *J. Proc. Linn. Soc., Bot.* 3: 90 (1859)

basionym for *Corymbia ptychocarpa* (F.Muell.) K.D.Hill & L.A.S.Johnson, *Telopea* 6: 250 (1995) (Myrtaceae)

Type citation: 'Ad rivulos rupestres necnon secus amnes exsiccantes versus originem fluviorum Wentworth, Wickham et Limmen Bight River. Anth. Mart., April'.

The holotype collection by Mueller from the Gulf of Carpentaria was made on 22 July 1856 and is at K (Blake 1953; Chippendale 1988).

EBC Catalogue no. 55280; no record in Entry Book. Received at Kew in 1859. Donated by F. Mueller. Two large and four small fruit, one of the larger cut lengthways. This has a label in Mueller's hand: 'Eucalyptus ptychocarpa ferd Mueller Box–Stringybark tree of Gulf of Carpentaria, ferd. Mueller'. Fig. 6.

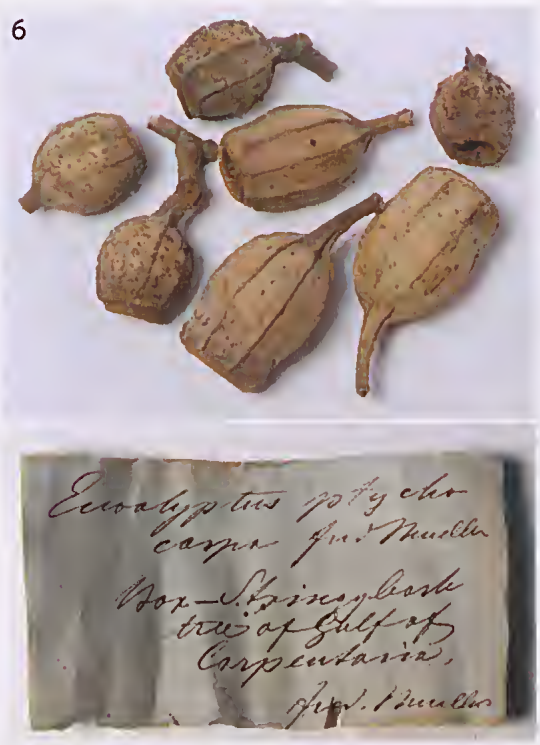

Figure 6. *Eucalyptus ptychocarpa* EBC55280
© Board of Trustees of the Royal Botanic Gardens, Kew.

6. *Helicia sayeriana* F. Muell., *Vict. Naturalist* 3: 93 (1886)

basionym for *Hollandaea sayeriana* (F.Muell.) L.S.Sm., *Proc. Roy. Soc. Queensland* 67: 39 (1956) (Proteaceae)

Type citation: 'On the Russell-River, W. Sayer'.

Hyland (1995) gave the locality as [Mt] Bellenden Ker and cited the holotype at MEL. The Russell River rises on the southern side of Bellenden Ker. There is an isotype at K consisting of a specimen in leaf and flower. William Sayer collected plants for Mueller in north Queensland in 1886–88 (George 2009).

EBC Catalogue no. 45009; Entry Book no. 87.1887. Donated by F. Mueller. Received at Kew in 1887. Two dehisced fruit. A label states: 'Hollandaea Sayeri Near entrance of the Russell River 1887'. Fig. 7.

7. *Hicksbeachia pinnatifolia* F. Muell., *S. Sci. Rec.* 3: 33 (1883) (Proteaceae)

Type citation: 'Near the Tweed; C. Fawcett, Esq.'.

Weston (1995) stated that he had not found the type. H. Charles Fawcett collected for Mueller in N.S.W. from 1875 to 1885. He was at the Tweed R. in 1883 (George 2009).

E8C Catalogue no. 45001; Entry Book no. 67.1884. Donated by F. Mueller. Received at Kew in 1884. Fourteen fruits, one cut in half. Three slips in Mueller's hand accompany this collection: 1, 'A large and two small fruit of Hicksbeachia, the former fit for germination Fresh April 1883' 'Nut tree Tweed March 1883 C. Fawcett'; 2, apparently only part of a note: 'as the autochthons eat this fruit Hicksbeachia pinnatifolia F v M 1884 Tweed'; 3, 'too dry for sowing; fit for museum'. These indicate that Mueller included fruits from more than one collection. Further, the part of the *Southern Science Record* in which the species was described was published in February 1883. It may be impossible to determine if any of the fruits are type material. Fig. 8.

8. *Kentia belmoreana* C. Moore & F. Muell., *Fragm.* 7: 99 (1870)

basionym for *Grisebachia belmoreana* (C.Moore & F.Muell.) Drude & H.Wendl., *Nachr. Königl. Ges. Wiss. Georg-Augusts-Univ.* 1875: 58 (1875); *Howea belmoreana* (C.Moore & F.Muell.) Becc., *Malesia* 1: 66 (1877) (Arecaceae)

Type citation: 'In insula Lord Howe's Island frequens, sed vix ultra altitudinem 1000' reperienda; Moore & Carron'.

The holotype is in MEL (Green 1994) and there is an isotype at BO (John Dowe, pers. comm.). Charles Moore and William Carron (with Robert D. Fitzgerald) visited Lord Howe Island in May–June 1869 (George 2009).

EBC Catalogue nos 35692, 35693; Entry Book no. 95.1876 (received as a single sample). Donated by F. Mueller. Received at Kew in 1876. No. 35693 (Fig. 9) has 10 fruit, and no. 35692 (Fig. 10) eight, as well as one cut open. No. 35692 has a label with the annotation 'Kentia Belmoreana' in a hand that I don't recognise and, in another hand, 'Perhaps K. Forsterianum Lord Howe's Island'.

9. *Kentia canterburyana* C. Moore & F. Muell., *Fragm.* 7: 101 (1870)

basionym for *Veitchia canterburyana* (C.Moore & F.Muell.) H.Wendl. ex Anon., *Gard. Chron.* 32: 327 (1872); *Hedyscepe canterburyana* (C.Moore & F.Muell.) H.Wendl. & Drude, *Linnaea* 39: 204 (1875) (Arecaceae)

Type citation: 'In regionibus altioribus insulae Lord

Figure 7. *Helicia sayeriana* EBC45009 © Board of Trustees of the Royal Botanic Gardens, Kew.
Figure 8. *Hicksbeachia pinnatifolia* EBC45001 © Board of Trustees of the Royal Botanic Gardens, Kew.

Howe's Island, nempe altitudine 1000–2000'. Moore et Fitzgerald'.

The holotype is in MEL (Green 1994) and there is an isotype at BO (John Dowe, pers. comm.). Charles Moore and Robert D. Fitzgerald (with William Carron) visited Lord Howe Island in May–June 1869 (George 2009).

EBC Catalogue no. 35690; Entry Book no. 95.1876. Donated by F. Mueller. Received at Kew in 1876. Eight fruits, one cut transversely to reveal seed. A label states: 'Kentia Canterburyana Howe's Island'. Fig. 11.

10. *Kentia mooreana* F.Muell., *Fragm.* 7: 101 (1870)

basionym for *Clinostigma mooreana* (F.Muell.) F.Muell., *Fragm.* 8: 235 (1874); *Clinostigma mooreanum* (F.Muell.) H.Wendl. & Drude, *Linnaea* 39: 218 (1875); *Lepdiorrhachis mooreana* (F.Muell.) O.F.Cook, *J. Heredity* 18: 408 (1927) (Arecaceae)

Type citation: 'In cacumine montis Gower insulae Lord Howe's Island, altitudine 2500 pedum'.

The holotype is at MEL, collected by C. Moore (Green 1994). The collector was Charles Moore, who (with William Carron and Robert D. Fitzgerald) visited Lord Howe Island in May–June 1869 and climbed Mt Gower (George 2009).

EBC Catalogue no. 35702; Entry Book no. 95.1876. Donated by F. Mueller. Received at Kew in 1876. 26 fruits, one cut open. A label states: 'Kentia Moorei Lord Howe's Island'. Fig. 12.

11. *Livistona alfredii* F.Muell., *Victorian Nat.* 9: 112 (1892) (Arecaceae)

EBC Catalogue no. 35756; Entry Book no. 121.1888. Donated by F. Mueller. Received at Kew in 1888. Three fruit and one seed. This has a blue 'Phytologic Museum of Melbourne' label but not in Mueller's hand: 'Livistona Mariae F. v. M. West Australia'. Fig. 13.

This collection is labelled as *Livistona mariae* but it appears to be *Livistona alfredii*. The fruits are 22–24 mm diam., approaching the size given by Rodd for *L. alfredii*, 25–35(–c. 40) mm, whereas those of *L. mariae* are 13–17 mm diam. (Rodd 1998). *Livistona mariae*, described by F. Mueller, *Fragm.* 8: 283 (1874), is endemic in a single gorge in the Northern Territory, where it was discovered by Ernest Giles in 1872. The year of receipt of this collection at Kew, the location 'West Australia' and the

Figure 9: *Kentia belmoreono* EBC335693 © Board of Trustees of the Royal Botanic Gardens, Kew.
Figure 10: *Kentio belmoreono* EBC35692 © Board of Trustees of the Royal Botanic Gardens, Kew.

present determination indicate that it is not from central Australia. *Livistona alfredii* is endemic in north-western Australia on the upper Ashburton and Fortescue Rivers, with a disjunct outlier in the Cape Range.

Although the holotype collection of *L. alfredii* at MEL has been attributed to John Forrest, collected in 1878 (Mueller 1878; Rodd 1998), it seems more likely that it was collected by his brother Alexander Forrest. John never explored the Hamersley Range area, whereas Alexander did extensive survey work there in 1878. At MEL there are two other collections from this period, one attributed to Forrest, collected in 1879, the other collected by McRae (probably Alexander Joseph) in 1879 and labelled Nickol Bay, where McRae lived at the time (George 2009). Until Mueller named *L. alfredii*, the species from the Hamersley Range was known as *L. mariae*. In the protologue, Mueller (1892) cited no specific type collection, mentioning its discovery 'fully thirty years ago ... on the Millstream ... Mr Beresford records this palm now also from the Fortescue-River and its tributaries, from the sources of the Robe-River, and from Cave's Creek.' No collection by Beresford is known. The 'thirty years ago' given by Mueller probably refers to a sighting by Francis Gregory on the Fortescue R. on 6 June 1861 (Gregory & Gregory 1884). For the present it is not possible to decide which of the early collections the material at Kew represents or if it is part of the type.

The type citation for *L. mariae* is 'Celeber Australiae centralis geographus Ernestus Giles palmam fortasse conspecificam in valle "Glen of Palms" montium Gillii detexit'. Rodd (1998) selected as lectotype a sheet at MEL labelled 'Gills Range, Giles' and discussed a second sheet labelled 'Gills (Macdonells) Range, E. Giles' (which is probably an isolectotype though not specified as such by Rodd). The locality on these sheets may not be correct, since the species grows only in Palm Valley where the Finke River cuts through the Krichauff Range. Giles discovered the palms there in September 1872. He was in the George Gill Range, which lies to the west, late in 1873. There is no locality named Mount Gill.

12. *Musa banksii* F.Muell., *Fragm.* 4: 132 (1864) (Musaceae)

Type citation: 'In vallibus silvarum ad montem Elliot. Fitzalan'.

The holotype is at MEL and an isotype BM (Ross 1987). Eugene Fitzalan collected widely for Mueller in Queensland between 1860 and 1882 (George 2009). No date is recorded for this collection but, in a letter to August Petermann dated 26 August 1864, Mueller mentioned having recently received *Musa* from north-eastern Australia (Home *et al.* 2002).

EBC Catalogue no. 29543; Entry Book no. 61.1873. Donated by F. Mueller. Received at Kew in 1873. A hand of five fruit. There are no collection details with the specimen but there are no other collections this early. Fig. 14.

13. *Paederota densifolia* F. Muell., *Trans Philosoph. Soc. Victoria* 1: 107 (1855)

basionym for *Veronica densifolia* (F.Muell.) F.Muell., *Fragm.* 2: 137 (1861); *Chionohebe densifolia* (F.Muell.) Briggs & Ehrendorfer, *Contr. Herb. Australiense* 25: 2 (1976)

Figure 11: *Kentio conterburyona* EBC35690 © Board of Trustees of the Royal Botanic Gardens, Kew.
Figure 12: *Kentio mooreano* EBC35702 © Board of Trustees of the Royal Botanic Gardens, Kew.
Figure 13: *Livistonia olfredii* EBC35756 © Board of Trustees of the Royal Botanic Gardens, Kew.
Figure 14: *Muso bonksii* EBC29543 © Board of Trustees of the Royal Botanic Gardens, Kew.
Figure 15: *Poederoto densifolia* EBC47910 © Board of Trustees of the Royal Botanic Gardens, Kew.
Figure 16: *Pondonus forsteri* EBC34726 © Board of Trustees of the Royal Botanic Gardens, Kew.

Type citation: 'On the highest rocky summits of the Munyang Mtns (6–6,500 feet)'.

Briggs and Ehrendorfer (2006) selected as lectotype a collection from Munyang Mountains by Mueller in January 1855. They cited a further sheet at MEL and three at K as residual syntypes, with a further sheet at MEL a possible syntype. Munyang Mountains was an early name for Mt Kosciuszko, which Mueller climbed in the summer of 1854–55.

EBC Catalogue no. 47910; no record in Entry Book. Date of receipt at Kew not given. There are several dried pieces, one probably with a few fruit. A label in a hand that I don't recognise states: 'Paederota densifolia Mueller Australian Alps Alt. 6000 feet Dr. Mueller'. Fig. 15.

14. *Pandanus forsteri* C. Moore & F. Muell., *Fragm.* 8: 220 (1874) (Pandanaceae)

Type citation: 'In insula Howei a litore marino ad altitudinem 2000' montes adscendens, ubi omnibus ob res scientiae proficiscentibus observatus'.

No collector was cited directly in the protologue, but habit notes from both Charles Moore and James Fullagar were given. Green (1994) cited a collection by both Moore and Fullagar as syntype, represented at K and MEL, but it is more likely that there were two collections. Moore (with William Carron and Robert D. Fitzgerald) visited Lord Howe Island in May–June 1869, and Fullagar (with Lind, whose initials I have never seen) collected there in 1872–73 (George 2009). The sheet at MEL gives only Fullagar.

EBC Catalogue no. 34726; Entry Book no. 95.1876. Donated by F. Mueller. Received at Kew in 1876. One fruit. A label states: 'Pandanus Forsteri F.Muell Lord Howe's Island Fullagar F.Mueller 1876' and annotated 'Rec$^{d.}$ Aug. 1876.' Fig. 16.

Acknowledgements

I am grateful to Julia Steele, while Collections Manager of the Economic Botany Collection at Kew, for her assistance in locating and arranging for photographs of these collections. Mark Nesbitt, the present Curator, arranged for further images and assisted with historical information on the Collection. John Dowe, James Cook University, advised on the palm specimens, and Peter Weston, National Herbarium of New South Wales, on *Hicksbeachia*. My term as Australian Botanical Liaison Officer at the Royal Botanic Gardens, Kew, was supported by a grant from the Australian Biological Resources Study, Canberra.

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Australian Palms: natives only?

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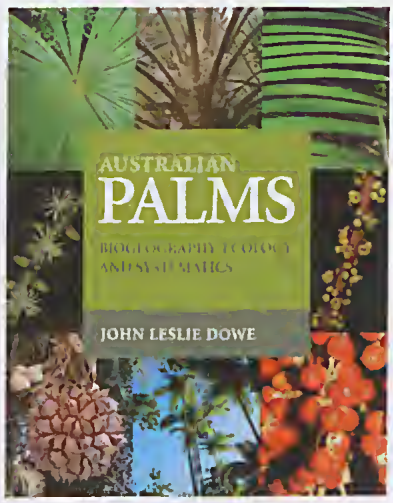

Australian Palms: Biogeography, Ecology and Systematics

John Leslie Dowe
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This book presents the culmination of more than twenty years research by the author. It provides a comprehensive systematic and taxonomic treatment of Australia's palm flora, which consists of 60 species in 21 genera, including six species on Lord Howe Island, Christmas Island and Norfolk Island. This is the first continental treatment for more than a century and provides a long overdue reference to this interesting group. It promises to be the essential reference guide to Australia's palms for many years to come.

The book is divided into twelve chapters. Chapter 1 provides a short overview of the higher level taxonomic representation and geographic distribution of Australia's palms. This chapter concludes with a paragraph devoted to "economic botany", and another paragraph serves to introduce the conservation ratings that are given for every species. Economic use of palms is given solely in terms of ornamental horticulture of Australian indigenous species. It is surprising that no mention is made of the extensive aboriginal usage of palms for roof thatch, baskets, fibre, fishing line and food. It seems that the focus of this book is essentially on Australian indigenous species since the time of white settlement of Australia (apart from an account of fossils and biogeography). This focus also leads to no mention of the introduced species being currently grown in Australia, e.g. *Phoenix dactylifera* (date palm), and *Elaeis guineensis* (oil palm) for food and potentially biofuel. Indeed this xenophobia is carried through into chapter 2, "Early documentation of Australian palms", which purely focuses on European explorers and botanists' accounts of Australian indigenous palms. The historical account is very interesting and provides a good context for the development of our understanding of Australia's palm flora, but surely some account of what is known of aboriginal knowledge would have been appropriate? Likewise there is no mention of the first records of introduced species in Australia, which would have provided useful information for assessing their subsequent spread.

Historical biogeography is the focus of the third chapter, which contains a descriptive review of fossil records from Australia and, interestingly, New Zealand. Inclusion of New Zealand is warranted in terms of its close floristic development, but it does make the exclusion of extra-Australian taxa from the majority of the book more puzzling. Later in the chapter co-occurrence of species in Australia and New Guinea is explained via review of descriptive scenarios. This style is continued in the following chapter, "Distribution and ecology", which covers a broad range of topics such as distribution, fire, climate, edaphic preferences, cyclones, altitude, demography and population genetics. These sections are well referenced and provide a very useful insight into these aspects of palm biology, which would otherwise be dispersed in literature inaccessible to the average reader.

A systematic account of Australian indigenous palms commences in the fifth chapter, which provides a very brief overview of the family classification, and the place of the Australian taxa therein. A figure depicts an evolutionary tree of the palm family, albeit in an ugly pixelated font, and provides a useful phylogenetic context for consideration of the diversity of Australia's indigenous palm flora. A very useful table provides a summary of the morphological features that are characteristic for subfamilies in Arecaceae, although 'spicate' is misspelt as 'spikate' in the Inflorescence section. Additionally a dichotomous key to subfamilies is provided at the end of the chapter, although this seems largely redundant given the excellent table preceding it. The concluding paragraph attempts to clarify usage of the family names, Arecaceae and Palmae, but goes awry. It incorrectly states that Arecaceae is an alternative name to Palmae, whereas Arecaceae is actually the correct name, and Palmae the alternative. Thankfully it does end by denoting Arecaceae as the preferred name in Australia, although it is regrettable that this section has muddied the water, rather than providing definitive clarification.

Chapters 6 to 10 each provide comprehensive treatment of one of the five subfamilies of Arecaceae. Each of these chapters commences with a description of the relevant subfamily, followed by about a page on classification and relationships of the subfamily. Treatments of genera follow, with a detailed morphological description and synonymy spanning about a page in length. Apart from the monospecific cases, generic descriptions are followed by dichotomous keys to species. These keys appear to be clear and work quite well in the couple of cases I tried. The species are numbered in the key according to their order in the following treatment, but since the species are alphabetically ordered the numbering is redundant, and it adds clutter rather than clarity. Indeed, it is surprising given the emphasis of the book on taxonomy and systematics, and inclusion of the latter in the book's title that no effort has been made to arrange species within genera on a phylogenetic basis. Perhaps this is indicative of our lack of knowledge at this level, and is consistent with the author's recent revision of *Livistona* (Dowe 2009), in which species were informally arranged into morphologically similar groups rather than on the basis of phylogenetic relationships.

The treatment of each species is extremely detailed and this is one of the main strengths of this book, providing detailed morphological descriptions of far greater length than would be possible in a typical flora treatment. The treatments of species consist of synonymy, description, common name, distribution and ecology (including conservation status), etymology, and notes, which provide assorted facts on history of discovery, naming, distinguishing features compared to similar species, and other information such as ecological observations. These treatments range in length from one to two pages of text and provide an unparalleled source of authoritative information on these aspects of Australia's indigenous palm flora.

The text is superbly complemented by a series of colour photographs for every species. A habitat photograph depicts the species in its natural environment and these are mostly clear, of high quality, and often strikingly beautiful. A few of the forest habitat photographs lose detail when reproduced at this size, but they are thankfully in the minority. Each species is also illustrated by a panel of 3–5 (typically 4) photographs that provide detail of diagnostic characters for each species, e.g. crown, leaves, petiole, inflorescence, flowers and fruits. Colour reproduction in the photographs appears to be accurate, with pictures of mature fruits being particularly eye-catching. However, there are cases where no attention has been paid to which photographs may provide the most help for a user of the book, e.g. *Livistona mariae* is keyed out entirely using leaf characters, and yet there is no photograph of a leaf for comparison when you want to check your identification! My only other criticism of these figures is the seemingly ad hoc use of scales: the vast majority of photographs have no scale, a few photographs of fruits have a ruler in view, some with units visible, some not, and very few have either a 5 or 10 cent Australian coin in the photograph. Finally a colour photograph is provided of a type specimen. Often these are quite scrappy specimens, even consisting of just a couple of fruits, so although botanists may find them interesting, they are of questionable usefulness for the average reader, and even for a botanist, the label information is usually not legible due to the

size of reproduction. It may have been preferable to eschew the photographs of type specimens for larger reproduction of the other photographs? Alternatively, if this work were to ever appear as an interactive identification product, à la the EUCLID DVD(Centre for Plant Biodiversity Research 2006) and Wattle CD (Maslin, coordinator, 2001), it would provide a perfect opportunity to incorporate larger, and more useful, photographs of type specimens.

A large, clear map of distribution is provided for every species. The legend for each map states, distribution is based on herbarium specimen data. I could not find a clear statement in the book as to when the maps were compiled or using data from which herbaria. The Acknowledgements section notes access to herbarium data was provided by Brisbane, Melbourne, Cairns, Townsville, Florida and Kew herbaria. If this is representative of the true data sources then it is troubling that half of the major Australian herbaria have not been consulted. A comparison of the maps in the book with those available on-line from Australia's Virtual Herbarium (AVH, http://www.rbg.vic.gov.au/avh), for species of *Calamus* revealed several discrepancies. In all cases the AVH maps had a wider distribution, and in most cases outliers hundreds of kilometres away. It is quite likely that some of these AVH records may be erroneous, but the AVH records also provide more continuity between disjunct distributions present in this book's maps, which would seem to suggest the book's maps are based on an incomplete sampling of available data. The 'missing' locality records found on the AVH were predominantly from the Sydney, Canberra and Adelaide herbaria, none of which were acknowledged for provision of herbarium data. It is unfortunate that the admirably clear presentation of the maps has been undermined by a seemingly incomplete assessment of all available data.

At first glance the layout is clear and has wonderful large photos. This holds especially true in the genera with only one or two species, because the figures remain adjacent to the relevant text, but in the more speciose genera, such as *Calamus*, with eight species, the text becomes badly disjointed from the figures. For example, the taxonomic treatment of *Calamus moti* starts at the bottom of p. 64, continues on the lower 1/3 of p. 65 (upper 2/3 with habitat photographs of *C. caryotoides*), lower 1/4 of p. 66 (upper 3/4 with detail photographs of *C. caryotoides*), lower 1/2 of p.67 (upper 1/2 with map and type specimen of *C. caryotoides*), and finishing the treatment of *C. moti* with a sentence on p. 68, the rest of which has the habitat photograph of *C. moti* and commencement of the textual treatment of *C. muelleri*. Detail photographs, map and type specimen of *C. moti* are on pp. 69 and 70, accompanying the rest of the text for *C. muelleri*, and the start of the treatment of *C. radicalis*. If this sounds confusing, it's because it is! It is very frustrating for the reader to be forced to continually flip backwards and forwards through pages to compare figures and text of a species. It seems that unfortunately the effort to incorporate many large attractive photographs has resulted in a great reduction in usability.

Linospadix is a generic name that has been variously treated as either masculine or feminine (Dowe & Ferrero 2001). If treated as feminine some specific epithets end in 'a', e.g. *L. monostachya*, or if treated as masculine, these end in 'os' or 'us', e.g. *L. monostachyos*. In previous treatments by the author (Dowe & Irvine 1997; Dowe & Ferrero 2001) the feminine gender was adopted for this genus, in keeping with general usage at the time and indeed the author felt so strongly about the issue that, 'A proposal to conserve *Linospadix*, [...] as having a feminine gender, has been accepted for publication in Taxon (Dowe & Henderson, in press)' (Dowe & Ferrero 2001). Despite extensive literature searches I could find no record of this 'in press' proposal having been published. It is puzzling that in this book the author has changed his mind and adopted the masculine gender for the genus, without any discussion or justification whatsoever. This is particularly confusing for potential readers since feminine usage is still prevalent in state floras and censuses. It is disappointing that this book reignites confusion on this issue, rather than authoritatively providing clarity.

Doubtful and excluded names are the subject of the eleventh chapter. Interestingly this includes three 'non-Australian' species that are naturalised, i.e. *Phoenix canariensis, P. dactylifera* and *Syagrus romanzoffianum*. There is no context given for why these species are suddenly included here, despite the complete absence of non-Australian species throughout the rest of the book.

This becomes more peculiar given that more than half of the species naturalised in Australia are not included in this section, e.g. *Caryota mitis*, *Chamaerops humilis*, *Sabal palmetto* and *Washingtonia filifera* (http://www.chah.gov.au/chah/apc/interim/Arecaceae.pdf). All of these species should have been included in the main part of the book, fully described, illustrated and included in the keys, which would facilitate their identification, and recording of their distribution and spread.

Chapter 12 consists of a dichotomous key enabling identification of all species of indigenous palms in the field. The key seems to be clear and works relatively well, but, as pointed out by the author, due to limited vegetative variation amongst some species, it does resort to using floral and fruit characters in some parts, which will quite often limit its usefulness in the field. The limitation of vegetative characters is understandable; I find it more disappointing that introduced taxa are not included in the key. The book includes excellent information on the conservation status of indigenous species, but surely also providing the means to identify naturalised or incipiently naturalised species is critical to conservation efforts and protection of our environment? Species in the key are unnumbered and there is no page reference given, so after keying out to a species, the user must consult the index to locate the species treatment.

A glossary of terms is provided, but it doesn't appear to be particularly accessible due to having no illustrations at all. This is one of the only palm books I have ever seen that does not have explanatory diagrams of basic features such as leaves, leaflets, inflorescence types etc. This is a major deficiency of the book that will seriously compromise its accessibility for the non-specialist, and all the more puzzling since the author provided excellent explanatory diagrams and descriptions in his recent taxonomic account of *Livistona* (Dowe 2009). The old saying, 'a picture is worth a thousand words', rings true when confronted, for example, with the definition of 'hastula' – 'a flap of tissue borne at the insertion of the lamina on the petiole of a palmate leaf'. This definition contains three terms that are defined elsewhere in the glossary, lamina, petiole and palmate. I'd contend that if the reader has a level of understanding that such terms need to be defined, they will have great difficulty visualising what a hastula is from this definition. Instead, clear line diagrams could have easily and unambiguously illustrated this and other features. Lenticellular, floccose and pruinose are missing from the glossary, and a definition is also missing for 'pistil', even though the definition of 'pistillate' is, 'bearing a pistil', and pistil is also referred to in definitions for stigma, style and unisexual. The definition for 'stamen' incorrectly gives a definition for a filament. Abbreviations, asl, bp, dbh and Mya are frequently used, but I did not come across definitions in the text or glossary.

Finally, the index appears to provide a comprehensive listing of all occurrences of each particular entry in the book. However, that does create a problem – entries will often refer to several pages, in some cases up to 13, so the reader is forced to guess which page will have the commencement of a species' treatment. This is extremely frustrating, and could have been easily avoided by using bold text for the listing of the first page of the relevant treatment of a species.

Australian Palms certainly represents a magnificent achievement by the author and publisher. The introductory reviews, detailed descriptions, associated information, and high quality and abundant photographs, together provide the most complete and authoritative guide available for our indigenous palm flora. It is a shame then that issues such as poor layout, lack of explanatory diagrams, deficiencies in the glossary, maps and index all combine to make using this book a frustrating experience rather than a rewarding one. Also, the decision to restrict the scope of the species coverage to palms indigenous to Australia, rather than the species that grow here compromises and restricts the usefulness of this book. Purely on the basis of content, this book would be highly recommended, and indeed it will be the essential reference for botanists that need a reference to our palms, but given its shortcomings and price, it may end up reaching a smaller audience than such a work deserves.

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